SCXI™

SCXI-1141/1142/1143 User Manual

May 2007
371748E-01

NATIONAL INSTRUMENTS™

Worldwide Technical Support and Product Information

ni.com

National Instruments Corporate Headquarters

11500 North Mopac Expressway Austin, Texas 78759-3504 USA Tel: 512 683 0100

Worldwide Offices

Australia 1800 300 800, Austria 43 662 457990-0, Belgium 32 (0) 2 757 0020, Brazil 55 11 3262 3599, Canada 800 433 3488, China 86 21 5050 9800, Czech Republic 420 224 235 774, Denmark 45 45 76 26 00, Finland 385 (0) 9 725 72511, France 33 (0) 1 48 14 24 24, Germany 49 89 7413130, India 91 80 41190000, Israel 972 3 6393737, Italy 39 02 413091, Japan 81 3 5472 2970, Korea 82 02 3451 3400, Lebanon 961 (0) 1 33 28 28, Malaysia 1800 887710, Mexico 01 800 010 0793, Netherlands 31 (0) 348 433 466, New Zealand 0800 553 322, Norway 47 (0) 66 90 76 60, Poland 48 22 3390150, Portugal 351 210 311 210, Russia 7 495 783 6851, Singapore 1800 226 5886, Slovenia 386 3 425 42 00, South Africa 27 0 11 805 8197, Spain 34 91 640 0085, Sweden 46 (0) 8 587 895 00, Switzerland 41 56 2005151, Taiwan 886 02 2377 2222, Thailand 662 278 6777, Turkey 90 212 279 3031, United Kingdom 44 (0) 1635 523545

For further support information, refer to the *Technical Support Information* document. To comment on National Instruments documentation, refer to the National Instruments Web site at ni.com/info and enter the info code feedback.

© 1994–2007 National Instruments Corporation. All rights reserved.

Important Information

Warranty

The SCXI-1141, SCXI-1142, and SCXI-1143 modules are warranted against defects in materials and workmanship for a period of one year from the date of shipment, as evidenced by receipts or other documentation. National Instruments will, at its option, repair or replace equipment that proves to be defective during the warranty period. This warranty includes parts and labor.

The media on which you receive National Instruments software are warranted not to fail to execute programming instructions, due to defects in materials and workmanship, for a period of 90 days from date of shipment, as evidenced by receipts or other documentation. National Instruments will, at its option, repair or replace software media that do not execute programming instructions if National Instruments receives notice of such defects during the warranty period. National Instruments does not warrant that the operation of the software shall be uninterrupted or error free.

A Return Material Authorization (RMA) number must be obtained from the factory and clearly marked on the outside of the package before any equipment will be accepted for warranty work. National Instruments will pay the shipping costs of returning to the owner parts which are covered by warranty.

National Instruments believes that the information in this document is accurate. The document has been carefully reviewed for technical accuracy. In the event that technical or typographical errors exist, National Instruments reserves the right to make changes to subsequent editions of this document without prior notice to holders of this edition. The reader should consult National Instruments if errors are suspected. In no event shall National Instruments be liable for any damages arising out of or related to this document or the information contained in it.

EXCEPT AS SPECIFIED HEREIN, NATIONAL INSTRUMENTS MAKES NO WARRANTIES, EXPRESS OR IMPLIED, AND SPECIFICALLY DISCLAIMS ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. CUSTOMER'S RIGHT TO RECOVER DAMAGES CAUSED BY FAULT OR NEGLIGENCE ON THE PART OF NATIONAL INSTRUMENTS SHALL BE LIMITED TO THE AMOUNT THERETOFORE PAID BY THE CUSTOMER. NATIONAL INSTRUMENTS WILL NOT BE LIABLE FOR DAMAGES RESULTING FROM LOSS OF DATA, PROFITS, USE OF PRODUCTS, OR INCIDENTAL OR CONSEQUENTIAL DAMAGES, EVEN IF ADVISED OF THE POSSIBILITY THEREOF. This limitation of the liability of National Instruments will apply regardless of the form of action, whether in contract or tort, including negligence. Any action against National Instruments must be brought within one year after the cause of action accrues. National Instruments shall not be liable for any delay in performance due to causes beyond its reasonable control. The warranty provided herein does not cover damages, defects, malfunctions, or service failures caused by owner's failure to follow the National Instruments installation, operation, or maintenance instructions; owner's modification of the product; owner's abuse, misuse, or negligent acts; and power failure or surges, fire, flood, accident, actions of third parties, or other events outside reasonable control.

Copyright

Under the copyright laws, this publication may not be reproduced or transmitted in any form, electronic or mechanical, including photocopying, recording, storing in an information retrieval system, or translating, in whole or in part, without the prior written consent of National Instruments Corporation.

National Instruments respects the intellectual property of others, and we ask our users to do the same. NI software is protected by copyright and other intellectual property laws. Where NI software may be used to reproduce software or other materials belonging to others, you may use NI software only to reproduce materials that you may reproduce in accordance with the terms of any applicable license or other legal restriction.

Trademarks

National Instruments, NI, ni.com, and LabVIEW are trademarks of National Instruments Corporation. Refer to the *Terms of Use* section on `ni.com/legal` for more information about National Instruments trademarks.

Other product and company names mentioned herein are trademarks or trade names of their respective companies.

Patents

For patents covering National Instruments products, refer to the appropriate location: **Help»Patents** in your software, the `patents.txt` file on your CD, or `ni.com/patents`.

WARNING REGARDING USE OF NATIONAL INSTRUMENTS PRODUCTS

(1) NATIONAL INSTRUMENTS PRODUCTS ARE NOT DESIGNED WITH COMPONENTS AND TESTING FOR A LEVEL OF RELIABILITY SUITABLE FOR USE IN OR IN CONNECTION WITH SURGICAL IMPLANTS OR AS CRITICAL COMPONENTS IN ANY LIFE SUPPORT SYSTEMS WHOSE FAILURE TO PERFORM CAN REASONABLY BE EXPECTED TO CAUSE SIGNIFICANT INJURY TO A HUMAN.

(2) IN ANY APPLICATION, INCLUDING THE ABOVE, RELIABILITY OF OPERATION OF THE SOFTWARE PRODUCTS CAN BE IMPAIRED BY ADVERSE FACTORS, INCLUDING BUT NOT LIMITED TO FLUCTUATIONS IN ELECTRICAL POWER SUPPLY, COMPUTER HARDWARE MALFUNCTIONS, COMPUTER OPERATING SYSTEM SOFTWARE FITNESS, FITNESS OF COMPILERS AND DEVELOPMENT SOFTWARE USED TO DEVELOP AN APPLICATION, INSTALLATION ERRORS, SOFTWARE AND HARDWARE COMPATIBILITY PROBLEMS, MALFUNCTIONS OR FAILURES OF ELECTRONIC MONITORING OR CONTROL DEVICES, TRANSIENT FAILURES OF ELECTRONIC SYSTEMS (HARDWARE AND/OR SOFTWARE), UNANTICIPATED USES OR MISUSES, OR ERRORS ON THE PART OF THE USER OR APPLICATIONS DESIGNER (ADVERSE FACTORS SUCH AS THESE ARE HEREAFTER COLLECTIVELY TERMED "SYSTEM FAILURES"). ANY APPLICATION WHERE A SYSTEM FAILURE WOULD CREATE A RISK OF HARM TO PROPERTY OR PERSONS (INCLUDING THE RISK OF BODILY INJURY AND DEATH) SHOULD NOT BE RELIANT SOLELY UPON ONE FORM OF ELECTRONIC SYSTEM DUE TO THE RISK OF SYSTEM FAILURE. TO AVOID DAMAGE, INJURY, OR DEATH, THE USER OR APPLICATION DESIGNER MUST TAKE REASONABLY PRUDENT STEPS TO PROTECT AGAINST SYSTEM FAILURES, INCLUDING BUT NOT LIMITED TO BACK-UP OR SHUT DOWN MECHANISMS. BECAUSE EACH END-USER SYSTEM IS CUSTOMIZED AND DIFFERS FROM NATIONAL INSTRUMENTS' TESTING PLATFORMS AND BECAUSE A USER OR APPLICATION DESIGNER MAY USE NATIONAL INSTRUMENTS PRODUCTS IN COMBINATION WITH OTHER PRODUCTS IN A MANNER NOT EVALUATED OR CONTEMPLATED BY NATIONAL INSTRUMENTS, THE USER OR APPLICATION DESIGNER IS ULTIMATELY RESPONSIBLE FOR VERIFYING AND VALIDATING THE SUITABILITY OF NATIONAL INSTRUMENTS PRODUCTS WHENEVER NATIONAL INSTRUMENTS PRODUCTS ARE INCORPORATED IN A SYSTEM OR APPLICATION, INCLUDING, WITHOUT LIMITATION, THE APPROPRIATE DESIGN, PROCESS AND SAFETY LEVEL OF SUCH SYSTEM OR APPLICATION.

Conventions

The following conventions are used in this manual:

<> — Angle brackets that contain numbers separated by an ellipsis represent a range of values associated with a bit or signal name—for example, AO <3..0>.

» — The » symbol leads you through nested menu items and dialog box options to a final action. The sequence **File»Page Setup»Options** directs you to pull down the **File** menu, select the **Page Setup** item, and select **Options** from the last dialog box.

— This icon denotes a note, which alerts you to important information.

— This icon denotes a caution, which advises you of precautions to take to avoid injury, data loss, or a system crash. When this symbol is marked on a product, refer to the *Read Me First: Safety and Radio-Frequency Interference* document for information about precautions to take.

— When symbol is marked on a product, it denotes a warning advising you to take precautions to avoid electrical shock.

— When symbol is marked on a product, it denotes a component that may be hot. Touching this component may result in bodily injury.

bold — Bold text denotes items that you must select or click in the software, such as menu items and dialog box options. Bold text also denotes parameter names.

italic — Italic text denotes variables, emphasis, a cross-reference, or an introduction to a key concept. Italic text also denotes text that is a placeholder for a word or value that you must supply.

`monospace` — Text in this font denotes text or characters that you should enter from the keyboard, sections of code, programming examples, and syntax examples. This font is also used for the proper names of disk drives, paths, directories, programs, subprograms, subroutines, device names, functions, operations, variables, filenames, and extensions.

Contents

Chapter 1
About the SCXI-1141/1142/1143

What You Need to Get Started 1-2
National Instruments Documentation 1-3
Installing Application Software, NI-DAQmx, and the DAQ Device 1-4
Installing the SCXI-1141/1142/1143 into an SCXI Chassis or a PXI/SCXI Combination Chassis 1-4
Installing the Terminal Block 1-4
Verifying the SCXI-1141/1142/1143 Installation in Software 1-5
Installing SCXI Chassis and Modules in Software 1-5
Troubleshooting the Self-Test Verification 1-5
Troubleshooting in NI-DAQmx 1-5

Chapter 2
Connecting Signals

Front Connector 2-1
Front Connector Signal Descriptions 2-3
Analog Input Channels 2-3
Digital Input and Output 2-6
Rear Signal Connector 2-7
Analog Output Signal Connections 2-11
Digital I/O Signal Connections 2-11

Chapter 3
Configuring and Testing

SCXI-1141/1142/1143 Software-Configurable Settings 3-1
Common Software-Configurable Settings 3-1
Gain/Input Range 3-1
Input Selection 3-2
Auto-Zero 3-2
Configurable Settings in MAX 3-2
NI-DAQmx 3-3
Creating a Global Channel or Task 3-3
Verifying the Signal 3-4
Verifying the Signal in NI-DAQmx Using a Task or Global Channel 3-4

Chapter 4
Theory of Operation

Power-Up State 4-1
Digital Control Circuitry 4-3
Input Amplifiers 4-3
Correcting Gain and Offset Errors 4-4
Lowpass Filters 4-5
Filter Theory 4-5
Performance of the SCXI-1141/1142/1143 Module Filters 4-6
Magnitude Response 4-6
Phase Response 4-8
Setting the Cutoff Frequency 4-11
Using the SCXI-1141/1142/1143 Module as an Antialiasing Filter 4-12
Using the External Clock Input 4-14
DC-Correction Circuitry and Overload Recovery 4-15
Filter Bypass Mode 4-16
Rear Connector Analog Outputs 4-16
Multiplexed Mode (Recommended) 4-16
Parallel Mode 4-17

Chapter 5
Using the SCXI-1141/1142/1143 Module

Developing Your Application in NI-DAQmx 5-1
Typical Program Flowchart 5-1
General Discussion of Typical Flowchart 5-3
Creating a Task Using DAQ Assistant or Programmatically 5-3
Adjusting Timing and Triggering 5-3
Configuring Channel Properties 5-4
Acquiring, Analyzing, and Presenting 5-7
Completing the Application 5-7
Developing an Application Using LabVIEW 5-7
Using a NI-DAQmx Channel Property Node in LabVIEW 5-9
Specifying Channel Strings in NI-DAQmx 5-10
Text Based ADEs 5-10
Programmable NI-DAQmx Properties 5-12
Calibration 5-13
External Calibration 5-13

Appendix A
Specifications

Appendix B
Removing the SCXI-1141/1142/1143 Module

Appendix C
Common Questions

Glossary

Index

Figures

Figure 2-1. Ground-Referenced Signal Connection....2-4
Figure 2-2. Floating Signal Connection....2-5
Figure 2-3. Ground-Referenced AC-Coupled Signal Connection....2-5
Figure 2-4. Ground Offset AC-Coupled Signal Connection....2-6
Figure 2-5. Floating AC-Coupled Signal Connection....2-6

Figure 4-1. SCXI-1141/1142/1143 Module Block Diagram....4-2
Figure 4-2. Ideal and Real Lowpass Filter Transfer Function Characteristics....4-5
Figure 4-3. Real and Ideal Filter Responses to a Step Input Signal....4-6
Figure 4-4. Typical Magnitude Response of the SCXI-1141/1142/1143 Module Filters....4-7
Figure 4-5. Typical Passband Responses of the SCXI-1141/1142/1143 Module....4-8
Figure 4-6. Phase Response Characteristics of the SCXI-1141/1142/1143 Module Filters....4-9
Figure 4-7. Phase Error of the SCXI-1141/1142/1143 Module....4-10
Figure 4-8. Unit Step Response of the SCXI-1141/1142/1143 Module....4-11
Figure 4-9. Aliasing of an Input Signal with a Frequency 0.8 Times the Sample Rate....4-12

Figure 5-1. Typical Program Flowchart for Voltage Measurement Channels....5-2

Figure A-1. SCXI-1141/1142/1143 Dimensions....A-5

Figure B-1. Removing the SCXI-1141/1142/1143 Module....B-2

Tables

Table 1-1. Accessories Available for the SCXI-1141/1142/1143 1-4

Table 2-1. Front Signal Pin Assignments 2-2
Table 2-2. Rear Signal Pin Assignments 2-8
Table 2-3. SCXI-1141/1142/1143 Rear Communication Signals 2-9
Table 2-4. SCXIbus to SCXI-1141/1142/1143 Module Rear Signal Connector to DAQ Device Pin Equivalencies 2-12

Table 4-1. Cutoff Frequency Ranges for the SCXI-1141/1142/1143 Module Prefilters and Postfilters 4-15

Table 5-1. NI-DAQmx Voltage Measurement Properties 5-4
Table 5-2. NI-DAQmx Thermocouple Measurement Properties 5-5
Table 5-3. NI-DAQmx RTD Measurement Properties 5-6
Table 5-4. NI-DAQmx Thermistor Measurement Properties 5-6
Table 5-5. NI-DAQmx Current Measurement Properties 5-6
Table 5-6. Programming a Task in LabVIEW 5-8

Table A-1. Settling Time with Respect to Cutoff Frequency A-3

Table C-1. Digital SIgnals on the SCXI-1141/1142/1143 ..... C-2

1

About the SCXI-1141/1142/1143

This chapter describes the SCXI-1141/1142/1143 module, and explains how to install and remove the hardware and software.

The SCXI-1141/1142/1143 module has eight lowpass filters and eight differential-input amplifiers. The SCXI-1141 has elliptic filters; the SCXI-1142, Bessel filters; and the SCXI-1143, Butterworth filters.

You can use the SCXI-1141/1142/1143 module for lowpass filtering and antialiasing applications as well as for general-purpose signal amplification and filtering. The SCXI-1141/1142/1143 module works with National Instruments E/M Series DAQ devices. You can use one DAQ device to control several SCXI-1141/1142/1143 modules, in combination with other SCXI modules in a chassis. Each SCXI-1141/1142/1143 module can multiplex its channels into a single channel of the DAQ device, although separate outputs are also available. You can multiplex the output of several SCXI-1141/1142/1143 modules into a single channel, thus greatly increasing the number of analog input signals that the DAQ device can digitize.

The SCXI-1304 shielded terminal block has screw terminals for easily connecting signals to the SCXI-1141/1142/1143 module and is the terminal block recommended for use with this module.

Refer to Appendix A, *Specifications*, for detailed SCXI-1141/1142/1143 module specifications.

What You Need to Get Started

To set up and use the SCXI-1141/1142/1143 module, you need the following:

- ❑ Hardware
  - SCXI-1141/1142/1143 module
  - One of the following terminal blocks:
    - SCXI-1304
    - SCXI-1305
  - An SCXI chassis or PXI/SCXI combination chassis
  - One of the following:
    - E/M Series DAQ device
    - SCXI-1600
  - A computer if using an SCXI chassis
  - Cabling, cable adapter, and sensors as required for your application
- ❑ Software
  - NI-DAQ
  - One of the following software packages:
    - LabVIEW
    - Measurement Studio
    - LabWindows™/CVI™
- ❑ Documentation
  - *Read Me First: Safety and Radio-Frequency Interference*
  - *DAQ Getting Started Guide*
  - *SCXI Quick Start Guide*
  - *SCXI-1141/1142/1143 User Manual*
  - Terminal block installation guide for your application
  - Documentation for your software

You can download NI documents from `ni.com/manuals`. To download the latest version of NI-DAQmx visit `ni.com` and click **Drivers and Updates**. In the **Product Line** drop-down menu locate **Multifunction**

DAQ. Select the appropriate information for your application in the remaining drop-down menus and click **Go**.

National Instruments Documentation

The SCXI-1141/1142/1143 User Manual is one piece of the documentation set for data acquisition (DAQ) systems. You could have any of several types of manuals depending on the hardware and software in the system. Use the manuals you have as follows:

- SCXI chassis or PXI/SCXI combination chassis manual—Read this manual for maintenance information on the chassis and for installation instructions.
- The *DAQ Getting Started Guide*—This document has information on installing NI-DAQ and the E/M Series DAQ device. Install these before you install the SCXI module.
- The *SCXI Quick Start Guide*—This document contains a quick overview for setting up an SCXI chassis, installing SCXI modules and terminal blocks, and attaching sensors. It also describes setting up the SCXI system in MAX.
- The SCXI hardware user manuals—Read these manuals next for detailed information about signal connections and module configuration. They also explain, in greater detail, how the module works and contain application hints.
- Accessory installation guides or manuals—Read the terminal block and cable assembly installation guides. They explain how to physically connect the relevant pieces of the system. Consult these guides when you are making the connections.
- The E/M Series DAQ device documentation—This documentation has detailed information about the E/M Series DAQ device that plugs into or is connected to the computer. Use this documentation for hardware installation and configuration instructions, specification information about the E/M Series DAQ device, and application hints.
- Software documentation—You may have both application software and NI-DAQ software documentation. NI application software includes LabVIEW, LabWindows/CVI, and Measurement Studio. After you set up the hardware system, use either your application software documentation or the NI-DAQ documentation to help you write your application. If you have a large, complex system, it is worthwhile to look through the software documentation before you configure the hardware.

- The following help file for software information:
  - **Start»Programs»National Instruments»NI-DAQ» NI-DAQmx Help**

Installing Application Software, NI-DAQmx, and the DAQ Device

Refer to the *DAQ Getting Started Guide* packaged with the NI-DAQmx software to install your application software, NI-DAQmx driver software, and the E/M Series DAQ device to which you will connect the SCXI-1141/1142/1143. NI-DAQ 8.3 or later is recommended to configure and program the SCXI-1141/1142/1143 module.

Note Refer to the *Read Me First: Radio-Frequency Interference* document before removing equipment covers or connecting or disconnecting any signal wires.

Installing the SCXI-1141/1142/1143 into an SCXI Chassis or a PXI/SCXI Combination Chassis

Refer to the *SCXI Quick Start Guide* to install the SCXI-1141/1142/1143 module.

Installing the Terminal Block

Table 1-1 shows the supported SCXI-1141/1142/1143 terminal blocks. Refer to the *SCXI Quick Start Guide* and the terminal block installation guide for more information about the terminal block.

Table 1-1. Accessories Available for the SCXI-1141/1142/1143

Accessory	Description
SCXI-1304	Screw terminal block—Mounts on the front of the SCXI-1141/1142/1143 module. It includes AC coupling circuitry and ground referencing through a 100 KΩ bias resistor on each channel.
SCXI-1305	BNC terminal block—Mounts on the front of the SCXI-1141/1142/1143 module. It is functionally equivalent to the SCXI-1304 terminal block.

Verifying the SCXI-1141/1142/1143 Installation in Software

Refer to the *SCXI Quick Start Guide* for information on verifying the SCXI installation.

Installing SCXI Chassis and Modules in Software

Refer to the *SCXI Quick Start Guide* for information on installing chassis and modules using NI-DAQmx in software.

Troubleshooting the Self-Test Verification

If the self-test verification did not verify the chassis configuration, complete the steps in this section to troubleshoot the SCXI configuration.

Troubleshooting in NI-DAQmx

- If you get a **Verify SCXI Chassis** message box showing the SCXI chassis model number, **Chassis ID: *x***, and one or more messages stating **Slot Number: *x* Configuration has module: SCXI-*XXXX*** or **1141/1142/1143, hardware in chassis is: Empty**, take the following troubleshooting actions:
  - Make sure the SCXI chassis is powered on.
  - Make sure all SCXI modules are properly installed in the chassis. Refer to the *SCXI Quick Start Guide* for proper installation instructions.
  - Make sure the cable between the SCXI chassis and E/M Series DAQ device is properly connected.
  - Inspect the cable connectors for bent pins.
  - Make sure you are using the correct NI cable assembly.
  - Test the E/M Series DAQ device to verify it is working properly. Refer to the E/M Series DAQ device help file for more information.

- If you get a **Verify SCXI Chassis** message box showing the SCXI chassis model number, **Chassis ID: *x***, and the message **Slot Number: *x* Configuration has module: SCXI-*XXXX*** or **1141/1142/1143, hardware in chassis is: SCXI-*YYYY***, **1141/1142/1143**, or **Empty**, complete the following troubleshooting steps to correct the error.
  1. Expand **NI-DAQmx Devices**.
  2. Right-click the SCXI chassis and click **Properties** to load the chassis configurator.
  3. Under the **Modules** tab, ensure that the cabled module is listed in the correct slot.
  4. If the cabled module is not listed in the correct slot, complete the following troubleshooting steps:
     a. If the cabled module is not listed in the correct slot and the slot is empty, click the drop-down listbox next to the correct slot and select the cabled module. Configure the cabled module following the steps listed in the *SCXI Quick Start Guide*. Click **OK**.
     b. If another module is displayed where the cabled module should be, click the drop-down listbox next to the correct slot and select the cabled module. A message box opens asking you to confirm the module replacement. Click **OK**. Configure the cabled module following the steps listed in the *SCXI Quick Start Guide*. Click **OK**.
- If you have more than one kind of SCXI module in the SCXI chassis, ensure that you have the highest priority SCXI module cabled to the E/M Series DAQ device. Refer to the *SCXI Quick Start Guide* to find out which SCXI module in the chassis should be cabled to the E/M Series DAQ device.
- After checking the preceding items, return to the *Troubleshooting the Self-Test Verification* section and retest the SCXI chassis.

If these measures do not successfully configure the SCXI system, contact NI. Refer to the *Technical Support Information* document for contact information.

2

Connecting Signals

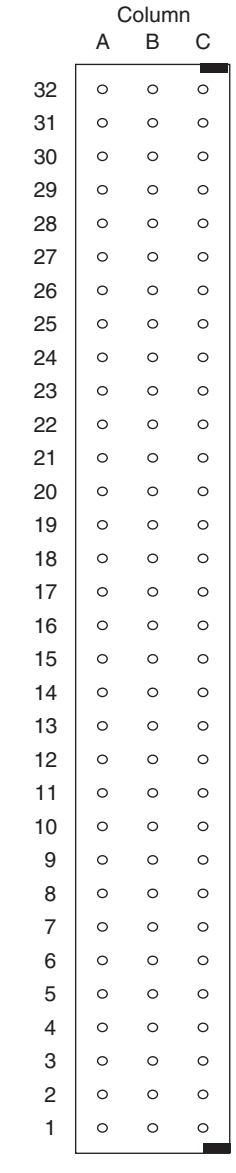
This chapter describes input and output signal connections to the SCXI-1141/1142/1143 module through the front and rear signal connectors.

Caution Connections that exceed any of the maximum ratings of input or output signals on the SCXI-1141/1142/1143 module can damage the SCXI-1141/1142/1143 module, the SCXIbus, any connected DAQ device, and the computer with which the DAQ device is used. NI is *not* liable for any damage resulting from such signal connections.

Front Connector

Table 2-1 shows the pin assignments for the SCXI-1141/1142/1143 module front connector.

Table 2-1. Front Signal Pin Assignments

Front Connector Diagram	Pin Number	Column A	Column B	Column C
	32	AI 0 +	NC	AI 0 –
	31	NC	NC	NC
	30	AI 1 +	NC	AI 1 –
	29	NC	NC	NC
	28	A GND	NC	A GND
	27	NC	NC	NC
	26	AI 2 +	NC	AI 2 –
	25	NC	NC	NC
	24	AI 3 +	NC	AI 3 –
	23	NC	NC	NC
	22	A GND	NC	A GND
	21	NC	NC	NC
	20	AI 4 +	NC	AI 4 –
	19	NC	NC	NC
	18	AI 5 +	NC	AI 5 –
	17	NC	NC	NC
	16	A GND	NC	A GND
	15	NC	NC	NC
	14	AI 6 +	NC	AI 6 –
	13	NC	NC	NC
	12	AI 7 +	NC	AI 7 –
	11	NC	NC	NC
	10	NC	NC	NC
	9	NC	NC	NC
	8	RSVD	NC	RSVD
	7	NC	NC	NC
	6	RSVD	NC	RSVD
	5	NC	NC	NC
	4	RSVD	NC	EXT CLK
	3	NC	NC	NC
NC means no connection.	2	D GND	NC	OUT CLK
RSVD means reserved.	1	NC	NC	NC

Front Connector Signal Descriptions

Pins	Signal Names	Description
A32, A30, A26, A24, A20, A18, A14, A12	AI+<0..7+>	Positive input channels—these pins connect to the noninverting inputs of the instrumentation amplifier of each channel.
C32, C30, C26, C24, C20, C18, C14, C12	AI–<0..7–>	Negative input channels—these pins connect to the inverting inputs of the instrumentation amplifier of each channel.
A28, A22, A16, C28, C22, C16	A GND	Analog ground—these pins connect to the module analog ground.
A2, C8	D GND	Digital ground—these pins connect to the module digital ground.
A8, A6, A4, C8	RSVD	Reserved—do not connect any signals to these pins.
C4	EXT CLK	External clock—you can use this signal to set the filter cutoff frequency.
C2	OUT CLK	Output clock—this signal has a frequency that is proportional to the cutoff frequency. You can use this signal to externally control the cutoff frequency.
Note: All other pins are not connected.		

Analog Input Channels

The SCXI-1141/1142/1143 module instrumentation amplifiers can reject any common-mode voltage within their common-mode input range caused by ground-potential differences between the signal source and the module. In addition, the amplifiers can reject common-mode noise pickup in the leads connecting the signal sources to the SCXI-1141/1142/1143 module. However, you should take care to minimize noise pickup. The common-mode rejection of the instrumentation amplifiers decreases significantly at high frequencies. The amplifiers do not reject normal-mode noise.

The maximum differential input voltage range of the SCXI-1141/1142/1143 module instrumentation amplifiers is a function of the gain of the amplifiers, *G*, and is equal to 5 V/*G*. The common-mode input range of the SCXI-1141/1142/1143 module, however, is not a function of gain—the differential input amplifier rejects common-mode signals as long as the signal at both inputs is within ±5 V of the module

analog ground. The inputs are protected against maximum input voltages of up to ±15 V powered off and ±30 V powered on.

Caution Exceeding the differential or common-mode input voltage limits distorts input signals. Exceeding the maximum common-mode input voltage rating can damage the SCXI-1141/1142/1143 module, the SCXIbus, and the DAQ device. NI is *not* liable for any damage resulting from such signal connections.

All eight channels have fully differential inputs, so you can ground-reference the signals you measure. If the signals connected to the differential amplified inputs are not ground referenced, connect a 100 kΩ resistor from the negative input to ground to provide a DC path for the input bias currents. If you do not do this, the bias currents of the instrumentation amplifiers of the nonreferenced channels charge up stray capacitances, resulting in uncontrollable drift and possible saturation.

Note The recommended SCXI-1304 or SCXI-1305 terminal block has all necessary circuitry for AC or DC coupling and for floating or ground-referenced signals. The *SCXI-1304 AC/DC Coupling Terminal Block Installation Guide* and *SCXI-1305 AC/DC Coupling BNC Terminal Block Installation Guide* have instructions for signal connection. Figures 2-2 through 2-5 provide supplemental information on connecting signals to the SCXI-1141/1142/1143 module.

Figure 2-1 illustrates how to connect a ground-referenced signal source to an SCXI-1141/1142/1143 module channel.

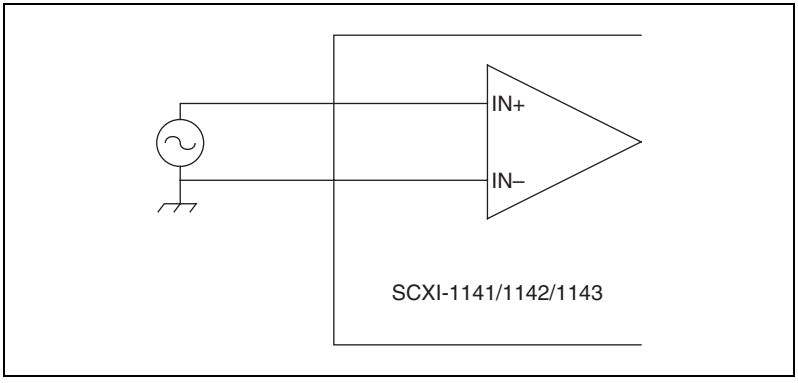


Figure 2-1. Ground-Referenced Signal Connection

Figure 2-2 illustrates how to connect a non-referenced (floating) signal source to an SCXI channel.

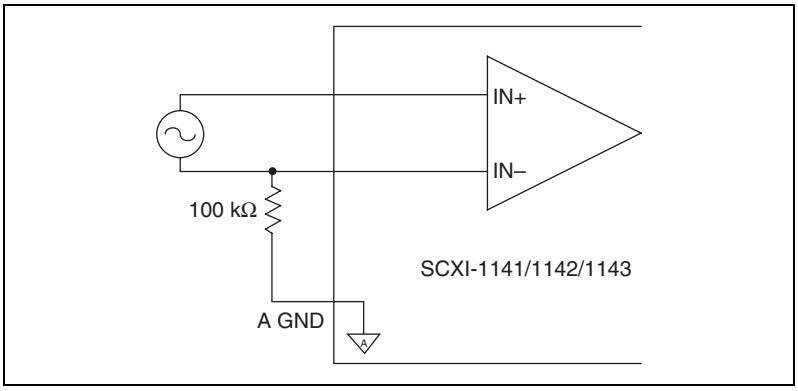


Figure 2-2. Floating Signal Connection

For AC-coupled signals, connect an external resistor from the AC-coupled input channel to ground. This provides a DC path for the amplifier input bias current. Typical resistor values range from 100 kΩ to 10 MΩ. This solution, although necessary, lowers the input impedance of the channel and introduces an additional DC offset voltage proportional to the product of the input bias current and the resistor value used. Using a 1 MΩ resistor results in ±200 µV of offset, which is insignificant in most applications. However, if you use larger-valued bias resistors, significant input offset can result. Lower-valued bias resistors increase loading of the source, which can result in gain error.

Figures 2-3 through 2-5 illustrate how to connect AC-coupled signals.

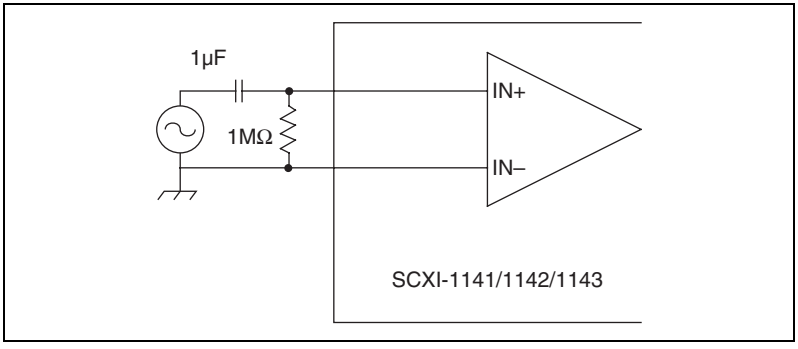


Figure 2-3. Ground-Referenced AC-Coupled Signal Connection

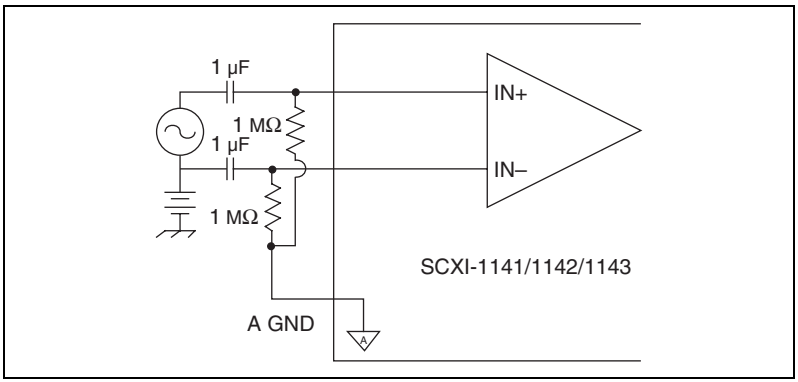


Figure 2-4. Ground Offset AC-Coupled Signal Connection

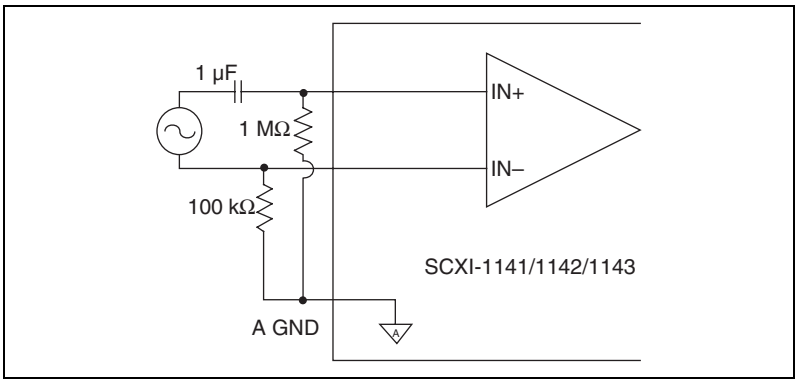


Figure 2-5. Floating AC-Coupled Signal Connection

Digital Input and Output

You can use the EXT CLK input pin on the front connector of the SCXI-1141/1142/1143 module to control filter cutoff frequency for special purposes. The clock should be a TTL-logic-level or CMOS-logic-level square wave, with a frequency of less than 2.5 MHz that is 100 times the desired cutoff frequency. The absolute maximum input voltage for the EXT CLK pin is 5.5 V with respect to D GND; the minimum input voltage is –0.5 V.

The OUT CLK pin on the front connector is a CMOS-logic-level output clock, which you can configure to have a frequency that is proportional to filter cutoff frequency.

See Chapter 4, *Theory of Operation*, for more details on using these two signals.

Rear Signal Connector

Note If you use the SCXI-1141/1142/1143 module with a National Instruments DAQ device and SCXI cable assembly, you do not need to read the remainder of this chapter. If you also use the SCXI-1180 feedthrough panel, the SCXI-1343 rear screw-terminal adapter, or the SCXI-1351 one-slot cable extender with the SCXI-1141/1142/1143 module, you should read this section.

Table 2-2 shows the pin assignments for the SCXI-1141/1142/1143 module rear signal connector. Pins without signal labels are not connected.

Table 2-2. Rear Signal Pin Assignments

Rear Connector Diagram	Signal Name	Pin Number	Pin Number	Signal Name
	NC	1	2	NC
	AI 0 +	3	4	AI 0 –
	AI 1 +	5	6	A GND
	AI 2 +	7	8	A GND
	AI 3 +	9	10	A GND
	AI 4 +	11	12	A GND
	AI 5 +	13	14	A GND
	AI 6 +	15	16	A GND
	AI 7 +	17	18	A GND
	NC	19	20	NC
	NC	21	22	NC
	NC	23	24	DIG GND
	SER DAT IN	25	26	SER DAT OUT
	DAQ D*/A	27	28	NC
	SLOT 0 SEL*	29	30	NC
	NC	31	32	NC
	DIG GND	33	34	NC
	NC	35	36	SCAN CLK
	SER CLK	37	38	NC
	NC	39	40	NC
	NC	41	42	NC
	RSVD	43	44	NC
	NC	45	46	NC
NC means no connection.	NC	47	48	NC
RSVD means reserved.	NC	49	50	NC

In parallel output mode, channel 0 is selected at the output multiplexer and is connected to AI 0. The seven other channels are directly connected to AI 1 through AI 7, respectively, on the rear connector.

In multiplexed mode, the AI 0 signal pair is used for sending all eight channels of the SCXI-1141/1142/1143, and analog signals from other modules, to the connected E/M Series DAQ device. If the module is cabled directly to the DAQ device, the other analog channels of the DAQ device are unavailable for general-purpose analog input because they are connected to the SCXI-1141/1142/1143 amplifier outputs. This means that connecting an SCXI-1180 module to the 50-pin breakout connector of the SCXI-1349, or other cable adapter assembly, may cause interference and incorrect measurements when the DAQ device is cabled to the SCXI-1141/1142/1143.

The communication signals between the DAQ device and the SCXI system are listed in Table 2-3. If the DAQ device is connected to the SCXI-1141/1142/1143, these digital lines are unavailable for general-purpose digital I/O.

Table 2-3. SCXI-1141/1142/1143 Rear Communication Signals

Pin	SCXI Signal Name	NI-DAQmx Device Signal Name	Direction	Description
5, 7, 9, 11, 13, 15, 17	AI <1..7>	N/A	Output	Analog outputs—these pins are the outputs of channels 1 through 7, regardless of the scanning mode.
6, 8, 10, 12, 14, 16, 18	A GND	AI GND	—	Analog ground—these pins connect to the module analog ground. They are used as the reference points for AI 1 + through AI 7 +.
24, 33	DIG GND	D GND	—	Digital ground—these pins supply the reference for E/M Series DAQ device digital signals and connect to the module digital ground.
25	SER DAT IN	P0.0	Input	Serial data in—this signal taps into the SCXIbus MOSI line to send serial input data to a module or Slot 0.

Table 2-3. SCXI-1141/1142/1143 Rear Communication Signals (Continued)

Pin	SCXI Signal Name	NI-DAQmx Device Signal Name	Direction	Description
26	SER DAT OUT	P0.4	Output	Serial data out—this signal taps into the SCXIbus MISO line to accept serial output data from a module.
27	DAQ D*/A	P0.1	Input	Board data/address line—this signal taps into the SCXIbus D*/A line to indicate to the module whether the incoming serial stream is data or address information.
29	SLOT 0 SEL*	P0.2	Input	Slot 0 select—this signal taps into the SCXIbus INTR* line to indicate whether the information on MOSI is being sent to a module or Slot 0.
36	SCAN CLK	AI HOLD, AI HOLD COMP	Input	Scan clock—a rising edge indicates to the scanned SCXI module that the E/M Series DAQ device has taken a sample and causes the module to advance channels.
37	SER CLK	EXT STROBE*	Input	Serial clock—this signal taps into the SCXIbus SPI CLK line to clock the data on the MOSI and MISO lines.
43	RSVD	RSVD	Input	Reserved.

Notes: All other pins are not connected.

An * means the signal is asserted low.

The signals on the rear signal connector are classified as analog output, digital I/O, or timing I/O signals.

Analog Output Signal Connections

Pins 3 through 17 of the rear signal connector are analog output signal pins. Pin 3 is the main output, and pin 4 is its reference signal. All eight channels are multiplexed onto this output when the module is software-configured for multiplexed scanning mode. In parallel scanning mode, the output of pin 3 is the output of one selected channel. Channel 0 is the power-up and reset default. When scanning multiple modules, you can also connect this output to the SCXIbus analog bus and the analog bus will drive this output.

Pins 5, 7, 9, 11, 13, 15, and 17 are direct outputs from channels 1 through 7, respectively. In parallel mode, all eight channels are available simultaneously at the rear connector. Pins 6, 8, 10, 12, 14, 16, and 18 are the reference signals for outputs 1 through 7.

Caution The SCXI-1141/1142/1143 module analog outputs are not overvoltage protected, although they are short-circuit protected. Applying external voltage to these outputs can result in damage to the SCXI-1141/1142/1143 module. NI is *not* liable for any damage resulting from such signal connections.

Digital I/O Signal Connections

Pins 24 through 27, 29, 33, 36, 37, and 43 constitute the digital I/O lines of the rear signal connector. Each of these pins is in one of three categories—digital input signals, digital output signals, and timing signals. Pins 24 and 33 are the digital ground reference for all of the DAQ device digital signals and are tied to the module digital ground.

The digital input signals are pins 25, 27, 29, and 37. Each digital line emulates an SCXIbus communication signal as follows:

- Pin 25 is SER DAT IN and is equivalent to the SCXIbus MOSI serial data input line.
- Pin 27 is DAQ D*/A and is equivalent to the SCXIbus D*/A line. Pin 27 indicates to the module whether the incoming serial stream on SER DAT IN is data (DAQ D*/A = 0) or address (DAQ D*/A = 1) information.
- Pin 29 is SLOT 0 SEL* and is equivalent to the SCXIbus INTR* line. Pin 29 indicates whether the data on the SER DAT IN line is being sent to Slot 0 (SLOT 0 SEL* = 0) or to a module (SLOT 0 SEL* = 1).
- Pin 37 is SER CLK and is equivalent to the SCXIbus SPI CLK line. Pin 37 is used to clock the serial data on the SER DAT IN line into the module registers.

The digital output signal is pin 26. Pin 26 is SER DAT OUT and is equivalent to the SCXIbus MISO serial data output line.

The digital I/O signals of the SCXI-1141/1142/1143 module correspond to the digital I/O lines of an E/M Series DAQ device. Table 2-4 lists the equivalencies.

Table 2-4. SCXIbus to SCXI-1141/1142/1143 Module Rear Signal Connector to DAQ Device Pin Equivalencies

SCXIbus Line	SCXI-1141/1142/1143 Rear Signal Connector	E/M Series DAQ Device
MOSI	SER DAT IN	DIO0
D*/A	DAQ D*/A	DIO1
INTR*	SLOT 0 SEL*	DIO2
SPI CLK	SER CLK	EXT STROBE*
MISO	SER DAT OUT	DIO4
Note: An * means the signal is asserted low.		

The digital timing signals are pins 36 and 43:

- Pin 36 is SCAN CLK, the signal used as a clock for the SCXI-1141/1142/1143 module multiplexer counter. The DAQ device pulses this signal at the end of each conversion if the module is in multiplexed mode.
- Pin 43 is a reserved digital input.

3

Configuring and Testing

This chapter discusses configuring the SCXI-1141/1142/1143 in MAX using NI-DAQmx, creating and testing a virtual channel, global channel, and/or task.

Notes NI recommends that you have NI-DAQmx 8.3 or later installed.

Refer to the *SCXI Quick Start Guide* if you have not already configured the chassis.

SCXI-1141/1142/1143 Software-Configurable Settings

This section describes how to set the gain/input signal range and how to configure your software for compatible sensor types. It also describes how to perform configuration of these settings for the SCXI-1141/1142/1143 in NI-DAQmx. For more information on the relationship between the settings and the measurements and how to configure settings in your application, refer to Chapter 4, *Theory of Operation*.

Common Software-Configurable Settings

This section describes the most frequently used software-configurable settings for the SCXI-1141/1142/1143. Refer to Chapter 4, *Theory of Operation*, for a complete list of software-configurable settings.

Gain/Input Range

Gain/input range is a software-configurable setting that allows you to choose the appropriate amplification to fully utilize the range of the E/M Series DAQ device. In most applications NI-DAQ chooses and sets the gain for you determined by the input range. This feature is described in Chapter 4, *Theory of Operation*. Otherwise, you should determine the appropriate gain using the input signal voltage range and the full-scale limits of the SCXI-1141/1142/1143 output. You can select a gain of 1, 2, 5, 10, 20, 50, or 100 on a per channel basis.

Input Selection

The front end of the SCXI-1141/1142/1143 includes a software configurable switch that allows you to programmatically connect the input channels of the SCXI-1141/1142/1143 to either the front connector or internal ground. Refer to Table 5-1, *NI-DAQmx Voltage Measurement Properties*, for details about the available input coupling modes supported by the SCXI-1141/1142/1143.

Auto-Zero

Setting the Auto-zero mode to *Once* improves the accuracy of the measurement. With auto-zero enabled, the inputs of the SCXI-1141/1142/1143 are internally grounded. The driver makes a measurement when the task begins and then subtracts the measured offset from all future measurements.

Although the DAQ driver does wait a certain amount of time for the signal to settle, it may not be long enough if the filter is set to very low cutoff frequency. This is especially true if the voltage ever goes out of range and the amplifier becomes saturated. You can manually zero out the offset by comparing the ground coupled value of a channel to its DC coupled value, then subtracting that offset from future measurements. This allows you to control the time allowed for the signals to settle.

Configurable Settings in MAX

Note If you are not using an NI ADE, using an NI ADE prior to version 8.3, or are using an unlicensed copy of an NI ADE, additional dialog boxes from the NI License Manager appear allowing you to create a task or global channel in unlicensed mode. These messages continue to appear until you install version 8.3 or later of an NI ADE.

This section describes where you can access each software-configurable setting in MAX. The location of the settings varies depending on the version of NI-DAQmx you use. Refer to the *DAQ Getting Started Guide* and the *SCXI Quick Start Guide* for more information on installing and configuring the hardware. You can use DAQ Assistant to graphically configure common measurement tasks, channels, or scales.

NI-DAQmx

Using NI-DAQmx, you can configure software settings, such as sensor type and gain/input signal range, in the following ways:

- Task or global channel in MAX
- Functions in your application

Note All software-configurable settings are not configurable both ways. This section only discusses settings in MAX. Refer to Chapter 4, *Theory of Operation*, for information about using functions in your application.

Depending on the terminal block in use, you can use the SCXI-1141/1142/1143 module to make the following types of measurements:

- Voltage input
- Thermocouple
- RTD
- Thermistors
- Current input

Creating a Global Channel or Task

To create a new voltage, temperature, or current input NI-DAQmx global task or channel, complete the following steps:

1. Double-click **Measurement & Automation** on the desktop.
2. Right-click **Data Neighborhood** and select **Create New**.
3. Select **NI-DAQmx Task** or **NI-DAQmx Global Channel**, and click **Next**.
4. Select **Analog Input**.
5. Select one of the following:
   - **Voltage**
   - **Temperature** and then select one of the following:
     - **Iex Thermistor**
     - **RTD**
     - **Thermocouple**
     - **Vex Thermistor**
   - **Current**

6. If you are creating a task, you can select a range of channels by holding down the <Shift> key while selecting the channels. You can select multiple individual channels by holding down the <Ctrl> key while selecting channels. If you are creating a channel, you can only select one channel. Click **Next**.
7. Name the task or channel and click **Finish**.
8. Select the channel(s) you want to configure. You can select a range of channels by holding down the <Shift> key while selecting the channels. You can select multiple individual channels by holding down the <Ctrl> key while selecting channels.

Note If you want to add channels of various measurement types to the same task, click the **Add Channels** button to select the measurement type for the additional channels.

9. Enter the specific values for your application in the **Settings** tab. Context help information for each setting is provided on the right side of the screen. Configure the input signal range using either **NI-DAQmx Task** or **NI-DAQmx Global Channel**. When you set the minimum and maximum range of **NI-DAQmx Task** or **NI-DAQmx Global Channel**, the driver selects the best gain for the measurement. You also can set it through your application.
10. If you are creating a task and want to set timing or triggering controls, enter the values in the **Task Timing** and **Task Triggering** tabs.
11. Click **Device** and select **Auto Zero** mode if desired.

Verifying the Signal

This section describes how to take measurements using test panels in order to verify signal, and configuring and installing a system in NI-DAQmx.

Verifying the Signal in NI-DAQmx Using a Task or Global Channel

You can verify the signals on the SCXI-1141/1142/1143 using NI-DAQmx by completing the following steps:

1. Expand **Data Neighborhood**.
2. Expand **NI-DAQmx Tasks**.
3. Click the task you created in the *Creating a Global Channel or Task* section.

4. Select the channel(s) you want to verify. You can select a block of channels by holding down the <Shift> key or multiple channels by holding down the <Ctrl> key. Click **OK**.
5. Enter the appropriate information on the **Settings** and **Device** tab.
6. Click the **Test** button.
7. Click the **Start** button.
8. After you have completed verifying the channels, click the **Stop** button.

You have now verified the SCXI-1141/1142/1143 configuration and signal connection.

Note For more information on how to further configure the SCXI-1141/1142/1143, or how to use LabVIEW to configure the module and take measurements, refer to Chapter 4, *Theory of Operation*.

4

Theory of Operation

This chapter contains an overview of the SCXI-1141/1142/1143 module and explains the operation of each functional unit of the module.

The SCXI-1141/1142/1143 module has eight software-controlled input channels that amplify and filter signals. Each channel has an output range of ±5 V and has an input amplifier with gains of 1, 2, 5, 10, 20, 50, and 100. You can independently set each amplifier gain. The analog inputs are overvoltage protected. The SCXI-1141/1142/1143 module filters are lowpass, 8th-order elliptic, Bessel, and Butterworth filters respectively that can have a cutoff frequency from 10 Hz to 25 kHz. All eight filters have the same cutoff frequency. The outputs of all eight channels are available at the rear connector.

The major components of the SCXI-1141/1142/1143 module are as follows:

- Digital control and calibration circuitry
- Input amplifiers
- Lowpass filters

Power-Up State

When the SCXI-1141/1142/1143 module is powered up or reset through software or the SCXI chassis reset button, the following states are defined:

- The gain of each amplifier is set to 1.
- Channel 0 is selected as the OUTPUT signal and the module defaults to multiplexed mode.
- All filters are placed in bypass mode.
- The external clock input is disabled.

The cutoff frequency of the filters and the output clock frequency are not defined at power-up.

The block diagram in Figure 4-1 illustrates the key functional components of the SCXI-1141/1142/1143 module.

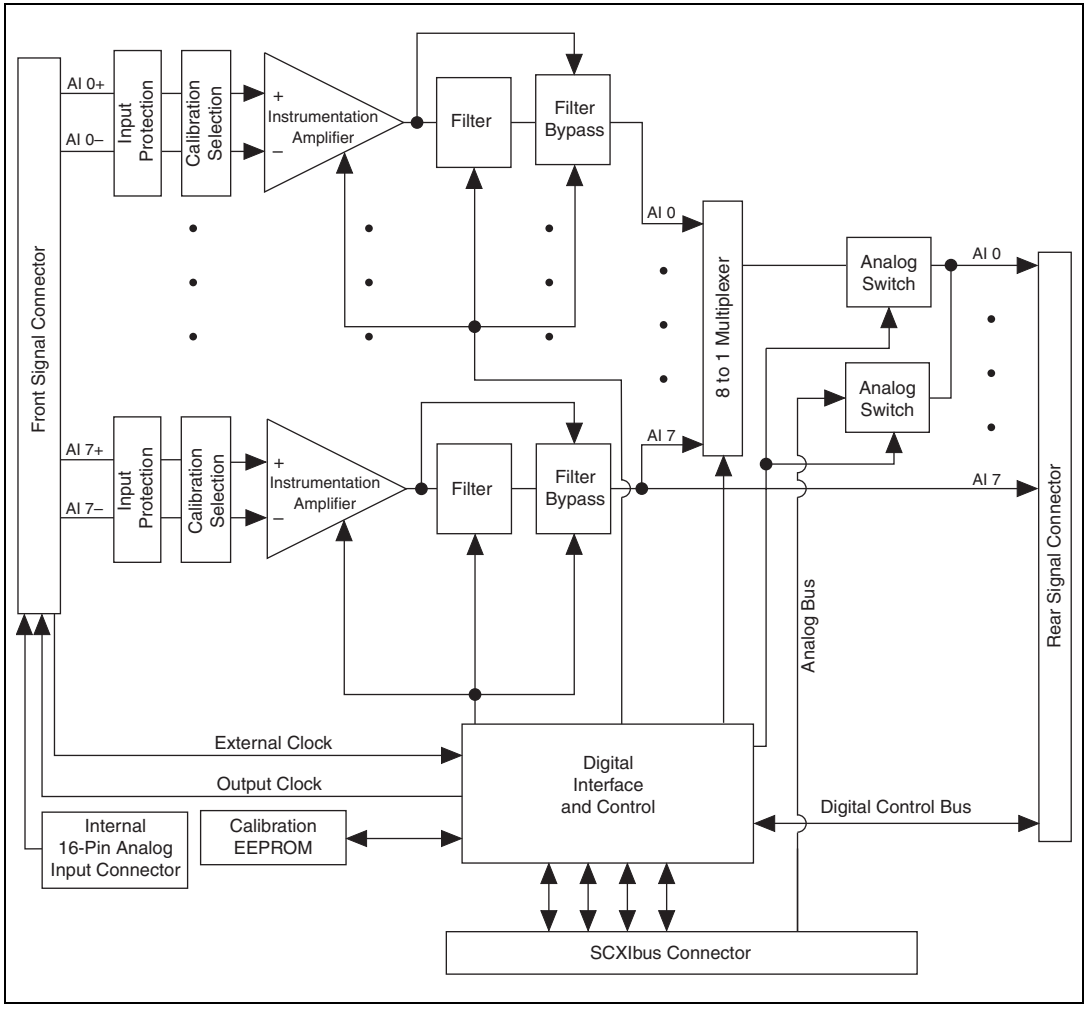


Figure 4-1. SCXI-1141/1142/1143 Module Block Diagram

Digital Control Circuitry

The digital control circuitry contains a Module ID (identification) register, a configuration register for the module, a gain register, and an EEPROM for storing gain-calibration constants.

The Module ID register contains 20 (hex) for the SCXI-1141 module, 35 (hex) for the SCXI-1142 module, and 34 (hex) for the SCXI-1143 module. You can read this module ID over the SCXIbus to determine the type of module that is in a particular slot.

Use the configuration register to select channels and configure the SCXI-1141/1142/1143 module for scanning, calibration, and control options.

The gain register sets the gain of each amplifier.

The frequency dividers control the filter cutoff frequency and the output clock frequency. For more information see the *Using the External Clock Input* section.

The EEPROM stores the calibration constants for each gain for all eight channels. Information in the EEPROM is retained when the module is power off. The SCXI-1141/1142/1143 module has calibration constants already stored in the EEPROM. You can modify these constants for your set of operating conditions. One set of constants is reserved and cannot be modified except at the factory, which ensures that you do not accidentally erase the default calibration constants. For more information on the EEPROM and calibration, see Chapter 5, *Using the SCXI-1141/1142/1143 Module*.

Input Amplifiers

The amplifiers provide gain to the differential signal between the inputs while rejecting common-mode noise voltages. The available gains are 1, 2, 5, 10, 20, 50, and 100. The output range of the amplifiers is ±5 V. Select the gain to prevent the output signals from reaching ±5 V, or distortion occurs.

The input amplifiers are fully differential amplifiers with input protection and calibration circuitry. The inputs are protected against input voltages up to ±15 V powered off and ±30 V powered on.

In general, to provide optimum measurement resolution and noise rejection, you can select as high a gain as will not cause the output to exceed this limit. However, total harmonic distortion (THD) increases at higher output levels, especially at higher input frequencies. If THD is of significant concern in a given application, a lower gain (one or two steps lower) may be more appropriate.

Correcting Gain and Offset Errors

The input amplifiers have intrinsic errors in their gains and in their DC offsets. To compensate for the gain errors, calibration constants are stored in the EEPROM for each gain and for each channel. These constants contain the adjustment factors used to correct for the gain errors. If you are using NI software, these constants are read automatically from the EEPROM and the appropriate correction factor is applied when the raw data is scaled to a voltage.

Gain errors are determined and calibration constants are loaded into the EEPROM at the factory. However, gain errors drift with temperature changes. You can add an additional set or subset of calibration constants to the EEPROM to optimize performance under a specific set of conditions. Details of this procedure are given in Chapter 5, *Using the SCXI-1141/1142/1143 Module*.

To account for offset errors, you can configure the module to send a 0 V differential signal through the amplifiers. The signal at the output represents the DC offset error and should be read and subtracted from all subsequent readings. Before reading this offset error on a channel, either set the filter to bypass mode or allow it to settle for several seconds. Average several readings to minimize noise errors. This procedure is called *calibration*.

Because the offset voltage changes with each gain, you should perform a new calibration each time the gain is changed. Offset errors also drift with changes in temperature, so you should update the offset correction periodically. Measurements made during the warm-up period of the module (approximately 20 minutes) and chassis are most susceptible to drifting offset errors.

Lowpass Filters

The SCXI-1141/1142/1143 module filters are 8th-order elliptic, Bessel, and Butterworth lowpass filters, respectively. These filters are a hybrid of a switched-capacitor and a continuous-time architecture, thus providing good cutoff frequency control while avoiding the sampling errors found in conventional switched-capacitor designs. To better acquaint you with these filters, this section describes what the filters do and presents examples of how to use them on the SCXI-1141/1142/1143 module.

Filter Theory

Filters are generally grouped into one of five classifications—*lowpass, highpass, bandpass, bandstop,* and *all-pass*. These classifications refer to the frequency range (the *passband*) of signals that the filter is intended to pass from the input to the output without attenuation. Because the SCXI-1141/1142/1143 modules use a lowpass filter, this discussion is limited to lowpass filters.

The ideal lowpass filter does not attenuate any input signal frequency components in the passband, which is defined as all frequencies below the *cutoff* frequency. The ideal lowpass filter completely attenuates all signal components in the *stopband*, which includes all frequencies above the cutoff frequency. The ideal lowpass filter also has a phase shift that is linear with respect to frequency. This linear phase property means that signal components of all frequencies are delayed by a constant time independent of frequency, thereby preserving the overall shape of the signal.

In practice, real filters can only approximate the characteristics of an ideal filter. Figure 4-2 compares the attenuation of a real filter and an ideal filter.

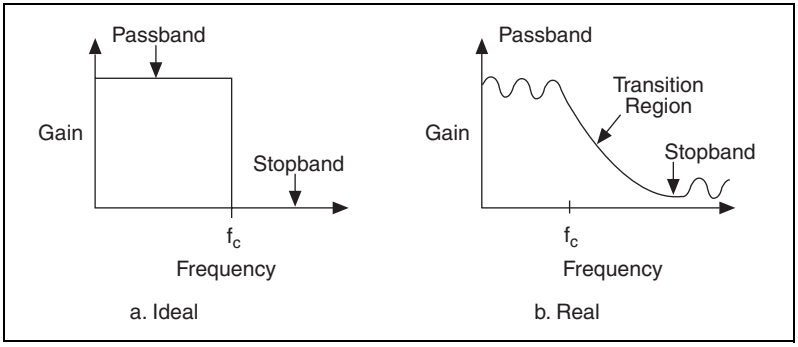


Figure 4-2. Ideal and Real Lowpass Filter Transfer Function Characteristics

As Figure 4-2b shows, a real filter has *ripple* (an uneven variation in attenuation versus frequency) in the passband, a transition region between the passband and the stopband, and a stopband with finite attenuation and ripple.

In addition, real filters have some nonlinearity in their phase response. This causes signal components at higher frequencies to be delayed by longer times than signal components at lower frequencies, resulting in an overall shape distortion of the signal. You can observe this when a square wave or step input is sent through a lowpass filter. An ideal filter simply smooths the edges of the input signal, whereas a real filter causes some ringing in the total signal because the higher-frequency components of the signal are delayed. Figure 4-3 shows examples of these responses to a step input.

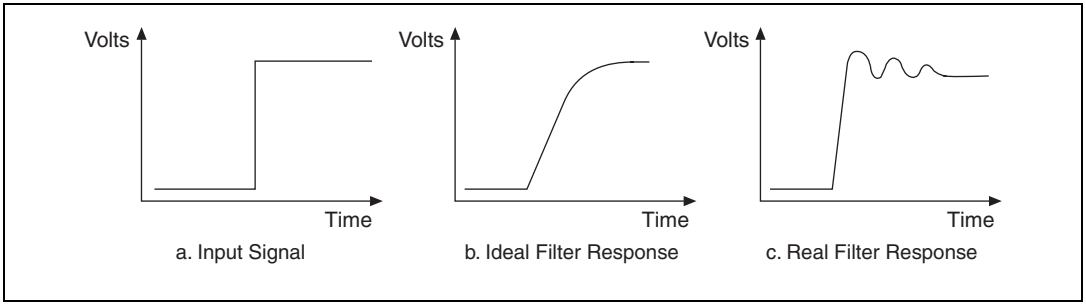


Figure 4-3. Real and Ideal Filter Responses to a Step Input Signal

Performance of the SCXI-1141/1142/1143 Module Filters

The SCXI-1141/1142/1143 module is elliptic, Bessel, and Butterworth filters, respectively. Each filter design optimizes a particular set of characteristics. Therefore, selecting the appropriate module depends on the application.

Magnitude Response

The magnitude response is the amplitude of the output at a given frequency. The typical magnitude response of the SCXI-1141/1142/1143 module filters is shown in Figures 4-4 and 4-5. Figure 4-4 shows the full magnitude response and Figure 4-5 shows the ripple in the passband. Both graphs are plotted with the frequency axis normalized to the cutoff frequency value of 1.

As Figure 4-4 shows, the SCXI-1141/1142/1143 module provides 80 dB attenuation above 1.5 times the cutoff frequency for the SCXI-1141 module, six times for the SCXI-1142 module, and 3.2 times for the SCXI-1143 module. The SCXI-1141, which incorporates an elliptic filter, is designed to provide maximum attenuation immediately above the cutoff frequency. Therefore, it is the ideal choice for applications in which you must remove signals very near the cutoff frequency.

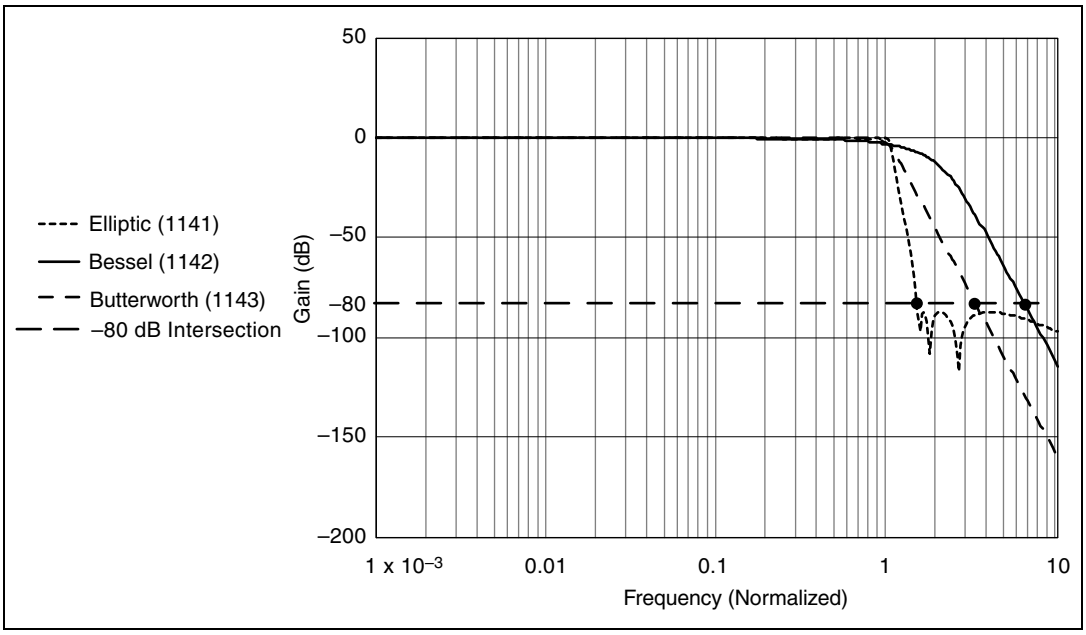


Figure 4-4. Typical Magnitude Response of the SCXI-1141/1142/1143 Module Filters

Figure 4-5 compares the magnitude response of the SCXI-1141/1142/1143 modules within the passband. The passband magnitude response begins to drop off immediately for the SCXI-1142 module. The SCXI-1141 performs much better than the SCXI-1142 in the passband, but it still exhibits about 0.1 dB of ripple in magnitude in the passband. The SCXI-1143 module Butterworth filter is designed for maximum flatness in the passband and is nearly perfectly flat in most of the passband. For this reason the SCXI-1143 module filter is the ideal choice for applications where flatness in the passband is critical.

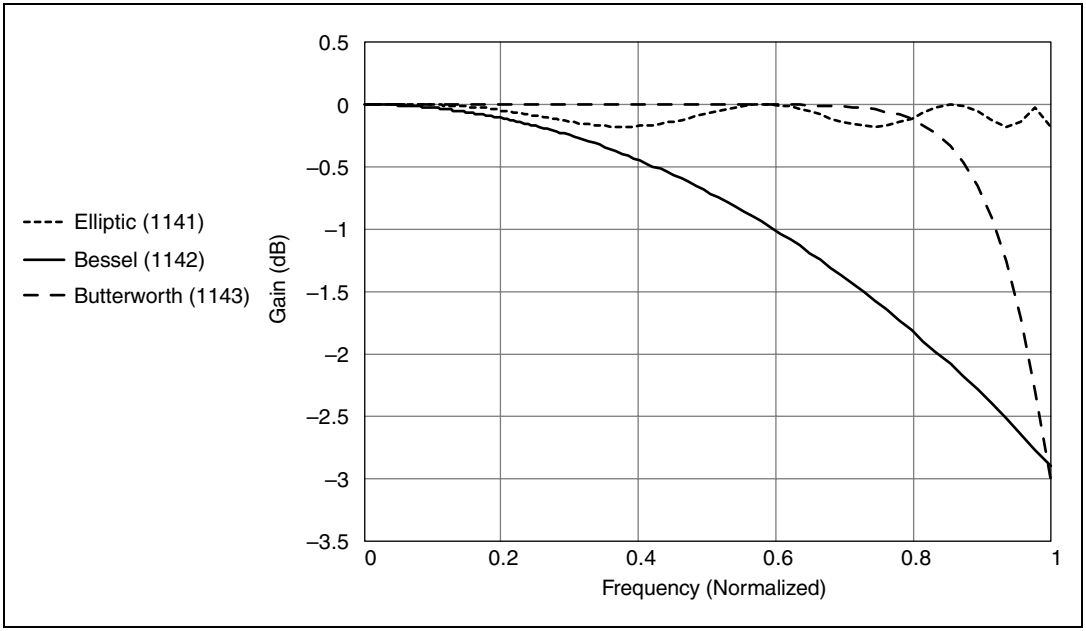


Figure 4-5. Typical Passband Responses of the SCXI-1141/1142/1143 Module

Phase Response

Figures 4-6 through 4-8 illustrate the phase response characteristics of the SCXI-1141/1142/1143 module filters. Figure 4-6 shows the phase shift as a function of frequency (normalized so that the cutoff frequency = 1). In an ideal filter, this would be a linear relationship. Figure 4-7 shows the deviation of the actual phase response from an ideal (linear) response. Generally, phase response is described in terms of the differential nonlinearity, or group delay. Group delay is defined as the negative derivative of the phase shift with respect to the frequency. In the ideal filter, group delay is a constant.

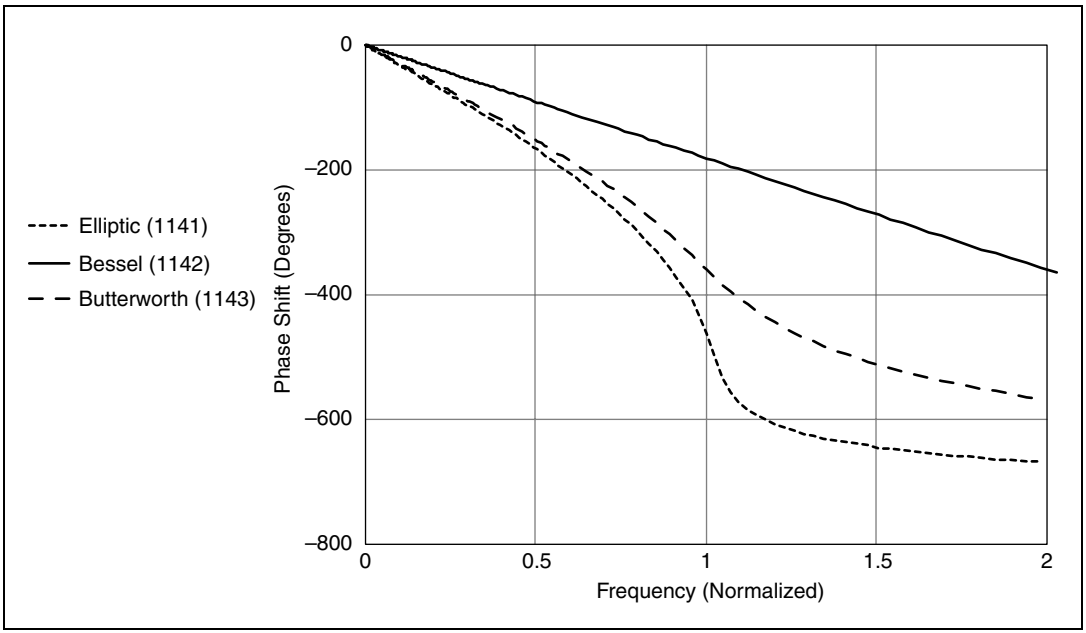


Figure 4-6. Phase Response Characteristics of the SCXI-1141/1142/1143 Module Filters

Figure 4-7 shows the advantages of the SCXI-1142 Bessel filter. The Bessel filter is designed for constant group delay at the expense of passband gain and stopband rolloff. As a result, the SCXI-1142 Bessel filter is the best choice when the phase information of a signal is important or a signal must maintain a constant delay regardless of its frequency components.

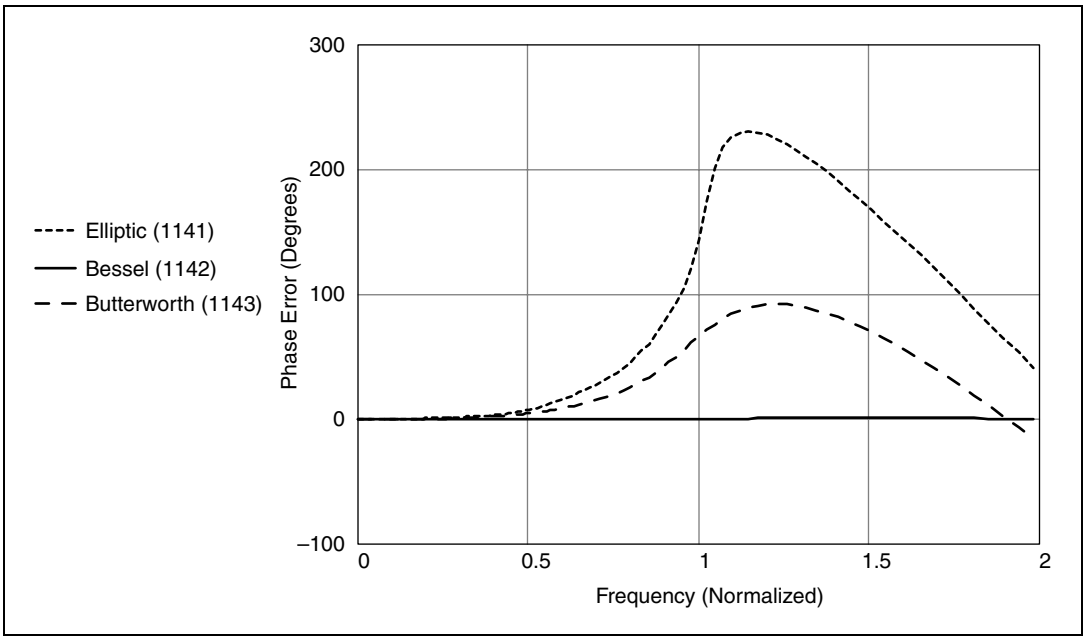


Figure 4-7. Phase Error of the SCXI-1141/1142/1143 Module

The most common effect of phase nonlinearity is ringing in response to a step input. As Figure 4-8 shows, the SCXI-1141 elliptic filter exhibits the most overshoot and ringing and the SCXI-1142 Bessel filter has no overshoot or ringing. The SCXI-1143 module Butterworth filter has a step response that is a compromise between the SCXI-1141 module and the SCXI-1142 module. The SCXI-1143 module filter has an overshoot, but it has less ringing than the SCXI-1141. You should consider the step response if the intended application is sensitive to overshoot or ringing. See Table A-1, *Settling Time with Respect to Cutoff Frequency*, for detailed settling specifications. Additionally, use care when selecting gain settings to assure that the input signal plus any overshoot voltage result in an output signal within the ±5 V range of the SCXI-1141/1142/1143 module.

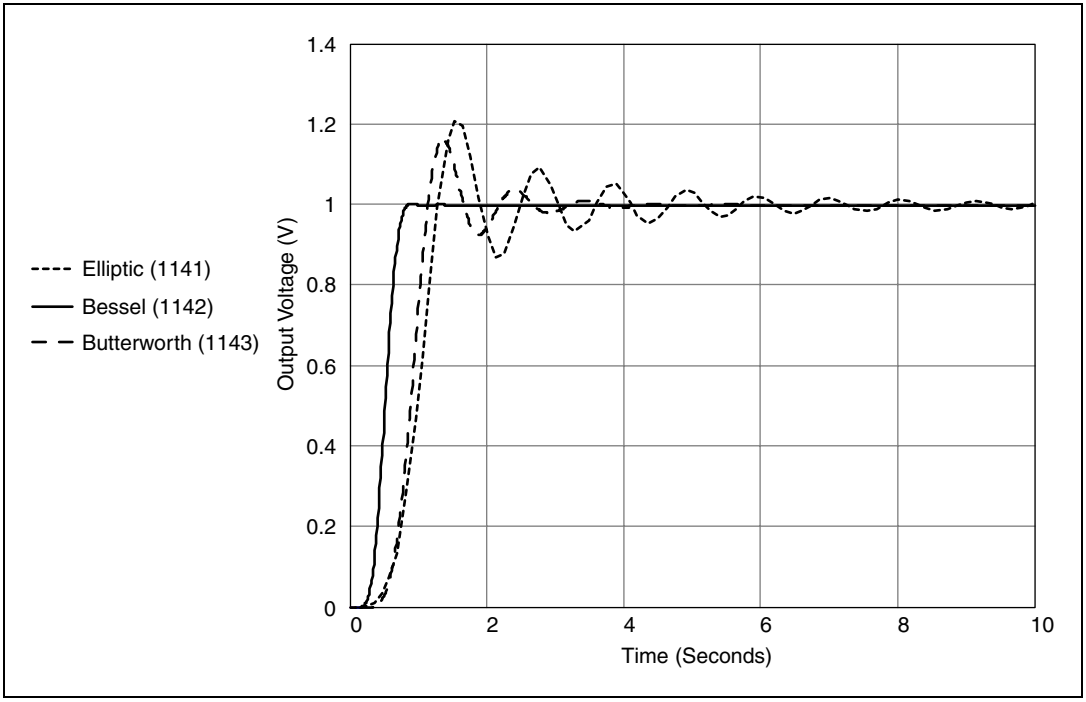


Figure 4-8. Unit Step Response of the SCXI-1141/1142/1143 Module

Setting the Cutoff Frequency

The cutoff frequencies of the filters in the SCXI-1141/1142/1143 module are set internally by dividing a base frequency of 100 kHz by an integer. You can determine the allowable cutoff frequencies for the SCXI-1141/1142/1143 module as follows:

$$f_c = \frac{100}{n} \text{ kHz}$$

where n is an integer ≥ 4 and $f_c \geq 10$ Hz. In other words, $f_c = \{25, 20, 16.7, 14.3, 12.5, ..., 0.01\}$ kHz.

If you are using NI software, the software automatically chooses a divisor, n, that best matches the cutoff frequency you specify and returns the actual cutoff frequency chosen.

The correct cutoff frequency depends on the application. If phase nonlinearity, ringing, passband ripple, or aliasing is a concern in the application, you may need to set the cutoff frequency several times higher

than the signal frequency range of interest. At frequencies much lower than the cutoff frequency, passband ripple and phase nonlinearity are much less noticeable. If you use the filter to prevent aliasing, you must set the cutoff frequency no higher than one-third of the frequency at which that channel is being sampled for the SCXI-1141 module, one-twelfth of the frequency for the SCXI-1142 module, or one-sixth of the frequency for the SCXI-1143 module.

Using the SCXI-1141/1142/1143 Module as an Antialiasing Filter

Aliasing, a phenomenon of sampled data acquisition systems, causes a high-frequency signal component to take on the identity of a low-frequency signal. Figure 4-9 shows an example of aliasing.

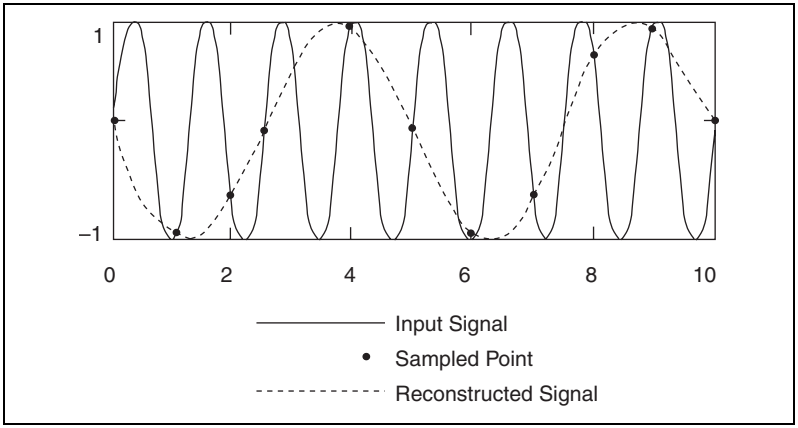


Figure 4-9. Aliasing of an Input Signal with a Frequency 0.8 Times the Sample Rate

The solid line depicts a high-frequency signal being sampled at the indicated points. However, when these points are connected to reconstruct the waveform, as shown by the dotted line, the signal appears to have a lower frequency. Any signal frequency with a frequency component greater than one-half of the sample rate is aliased and incorrectly analyzed as having a frequency below one-half of the sample rate. This limiting frequency of one-half the sample rate is known as the *Nyquist frequency.*

To prevent aliasing, you must remove all signal components with frequencies greater than the Nyquist frequency *before* sampling an input signaled. After an unfiltered signal is sampled and aliasing has occurred, it is impossible to accurately reconstruct the original signal. The SCXI-1141/1142/1143 module removes these high-frequency signals before they reach a DAQ device and cause aliasing.

Because the SCXI-1141 module stopband begins at 1.5 times the cutoff frequency, the Nyquist frequency should be at least 1.5 times the cutoff frequency. Thus, the rate at which the DAQ device samples a channel should be at least three times the filter cutoff frequency to acquire meaningful data.

The stopband for the SCXI-1142 module begins at six times the cutoff frequency, so you should sample it at a rate of 12 times the cutoff frequency to acquire meaningful data.

The stopband for the SCXI-1143 module begins at 3.2 times the cutoff frequency, so you should sample it at a rate of 6.4 times the cutoff frequency to acquire meaningful data.

For example, if a DAQ device is scanning all eight channels of the SCXI-1141 at a rate of 120,000 channels/s, the sample rate for each of the eight channels is:

$$\frac{120{,}000}{8} = 15{,}000 \text{ S/s}$$

and the cutoff frequency for the filters should be set no higher than:

$$\frac{15{,}000}{3} = 5{,}000 \text{ Hz}$$

Using this stopband, the filter attenuates the input signal by 80 dB or more. This is enough attenuation to prevent aliasing on DAQ systems with 12 bits of precision or less. On systems with more than 12 bits of precision or systems with extremely high amounts of out-of-passband noise, higher sampling rates or lower cutoff frequencies are necessary to prevent aliasing.

You can set the filter cutoff frequency closer to the sampling rate with the consequence of having some aliasing. If you can tolerate aliasing in the transition band, you can reduce the sampling rate to 2.6 times the cutoff frequency for the SCXI-1141 module, five times the cutoff frequency for the SCXI-1142 module, and 3.5 times the cutoff frequency for the SCXI-1143 module.

Using the External Clock Input

You can set the cutoff frequencies of filters in the SCXI-1141/1142/1143 module by using the external clock input in applications that require external control of the cutoff frequency or that require finer resolution than the module provides internally. The cutoff frequency for each filter using the external clock as a base is:

$$f_{ext}/(100 \times n)$$

where f_{ext} is the frequency of the external clock and n is an integer you select such that $2 \le n \le 2^{16}$.

When the frequency of the external clock changes, the cutoff frequency changes proportionally.

An external clock can control the SCXI-1141/1142/1143 module filters because they use a switched-capacitor architecture, which uses analog sampling. However, this technique is also susceptible to aliasing in much the same way as the digital sampling of a DAQ device (with a Nyquist frequency of one-half the external clock frequency). Analog sampling also creates high-frequency images of the signal because the output waveform has a staircase shape.

The SCXI-1141/1142/1143 module prevents these errors by using sets of prefilters and postfilters that do not sample the signal. A different set of prefilters and postfilters is used for each of 12 ranges of input frequencies. The prefilters reduce signals that can alias into a lower frequency by at least 40 dB, and the postfilters reconstruct the output waveform, reducing high-frequency images to at least –80 dB.

NI software automatically chooses the correct set of prefilters and postfilters when you specify a cutoff frequency. However, when the external clock input is used to set the cutoff frequency of a filter, you must still supply an approximate cutoff frequency so that the software can determine the appropriate set of prefilters and postfilters.

Table 4-1 gives the ranges of cutoff frequencies that the prefilters and postfilters use.

Table 4-1. Cutoff Frequency Ranges for the SCXI-1141/1142/1143 Module Prefilters and Postfilters

Range	Cutoff Frequencies
A	10–25 kHz
B	4.3–10 kHz
C	1.9–4.4 kHz
D	1.5–3.4 kHz
E	700 Hz–1.8 kHz
F	300–700 Hz
G	130–300 Hz
H	100–225 Hz
I	49–110 Hz
J	21–49 Hz
K	15–21 Hz
L	10–15 Hz

For best results, the cutoff frequency of a particular filter should remain within this range. If the cutoff frequency goes above this range, the prefilters and postfilters interfere with signals in the passband, causing additional attenuation near the cutoff frequency. If the cutoff frequency goes below this range, the level of protection from aliasing within the filter and from imaging in the output decreases.

DC-Correction Circuitry and Overload Recovery

The SCXI-1141/1142/1143 module incorporates circuitry that corrects for the DC gain and offset errors of the filters, leaving only the errors of the amplifiers. However, this correction circuitry takes approximately 15 s to completely respond to changes in these errors due to overload conditions (caused by driving the output signal outside of the ±5 V range) and upon power-up (no data should be taken during the first 15 s). Overload conditions result whenever the input signal exceeds ±5 V/gain. You must use a gain setting that prevents the maximum input signal from exceeding this limit, or the DC-correction circuitry will take 15 s to recover from overloads.

Filter Bypass Mode

You can bypass the filter of any channel through software control, thus making the unfiltered signal available at the output. The input amplifiers are not bypassed.

You can use the filter bypass to examine the effect that the filter has on the input signal. Using this mode, you can examine an input signal without the added effects of passband ripple and phase nonlinearities.

At power-up and at reset, all the channels of the SCXI-1141/1142/1143 module default to the filter bypass mode.

Rear Connector Analog Outputs

The connector signals A OUT<1..7> and A GND are the outputs of channels 1 through 7. You can configure the OUTPUT and OUTPUT REF signals as any channel (0 through 7) of the SCXI-1141/1142/1143 module or as the output of a channel passed along the SCXIbus from any other module in the chassis. Thus, the SCXI-1141/1142/1143 modules can present its outputs in both parallel and multiplexed modes.

Multiplexed Mode (Recommended)

In multiplexed mode, the output signals for channels 1 through 7 are sent to the rear signal connector but are usually ignored. All samples from the module are from the OUTPUT signal of the rear signal connector, which you can configure as the output of any channel of the SCXI-1141/1142/1143 module or as the output of any other module in multiplexed mode that is sending its output onto the SCXIbus. You can also configure the SCXI-1141/1142/1143 module to send any one of its outputs to the SCXIbus. Thus, in multiplexed mode only, one module in a chassis needs to be connected to a DAQ device. You can pass signals from the other modules to the DAQ device through the SCXIbus.

Multiplexed mode is also useful for performing scanning operations with the SCXI-1141/1142/1143 module. E/M Series devices support scanning. The SCXI chassis is programmed with a module scan list that dynamically controls which module sends its output to the SCXIbus during a scan. You can specify this list to scan the modules in any order, with an arbitrary number of channels for each module entry in the list. However, you must scan the channels on the SCXI-1141/1142/1143 module in consecutive, ascending order. After channel 7 is scanned, the module wraps back to

channel 0 and continues. You can program the SCXI-1141/1142/1143 module to start scans with any channel.

Parallel Mode

When the OUTPUT signal is configured as the rear connector output of channel 0, the rear signal connector simultaneously carries each of the rear connector outputs of the SCXI-1141/1142/1143 module channels on a different pin, and the module is in parallel mode. In this mode, you can use an SCXI-1180 feedthrough panel to make each of the outputs available at the front of the chassis. A DAQ device cabled to an SCXI-1141/1142/1143 module in parallel mode reads a separate output signal from the module on each of its analog inputs. You cannot multiplex the parallel outputs of a module onto the SCXIbus. Only a DAQ device directly cabled to the module has access to the outputs.

5

Using the SCXI-1141/1142/1143 Module

This chapter makes suggestions for developing your application and provides basic information regarding calibration.

Developing Your Application in NI-DAQmx

Note If you are not using an NI ADE, using an NI ADE prior to version 8.3, or are using an unlicensed copy of an NI ADE, additional dialog boxes from the NI License Manager appear allowing you to create a task or global channel in unlicensed mode. These messages continue to appear until you install version 8.3 or later of an NI ADE.

This section describes how to configure and use NI-DAQmx to control the SCXI-1141/1142/1143 in LabVIEW, LabWindows/CVI, and Measurement Studio. These ADEs provide greater flexibility and access to more settings than MAX, but you can use ADEs in conjunction with MAX to quickly create a customized application.

Typical Program Flowchart

Figure 5-1 shows a typical program voltage measurement flowchart for creating a task to configure channels, take a measurement, analyze the data, present the data, stop the measurement, and clear the task.

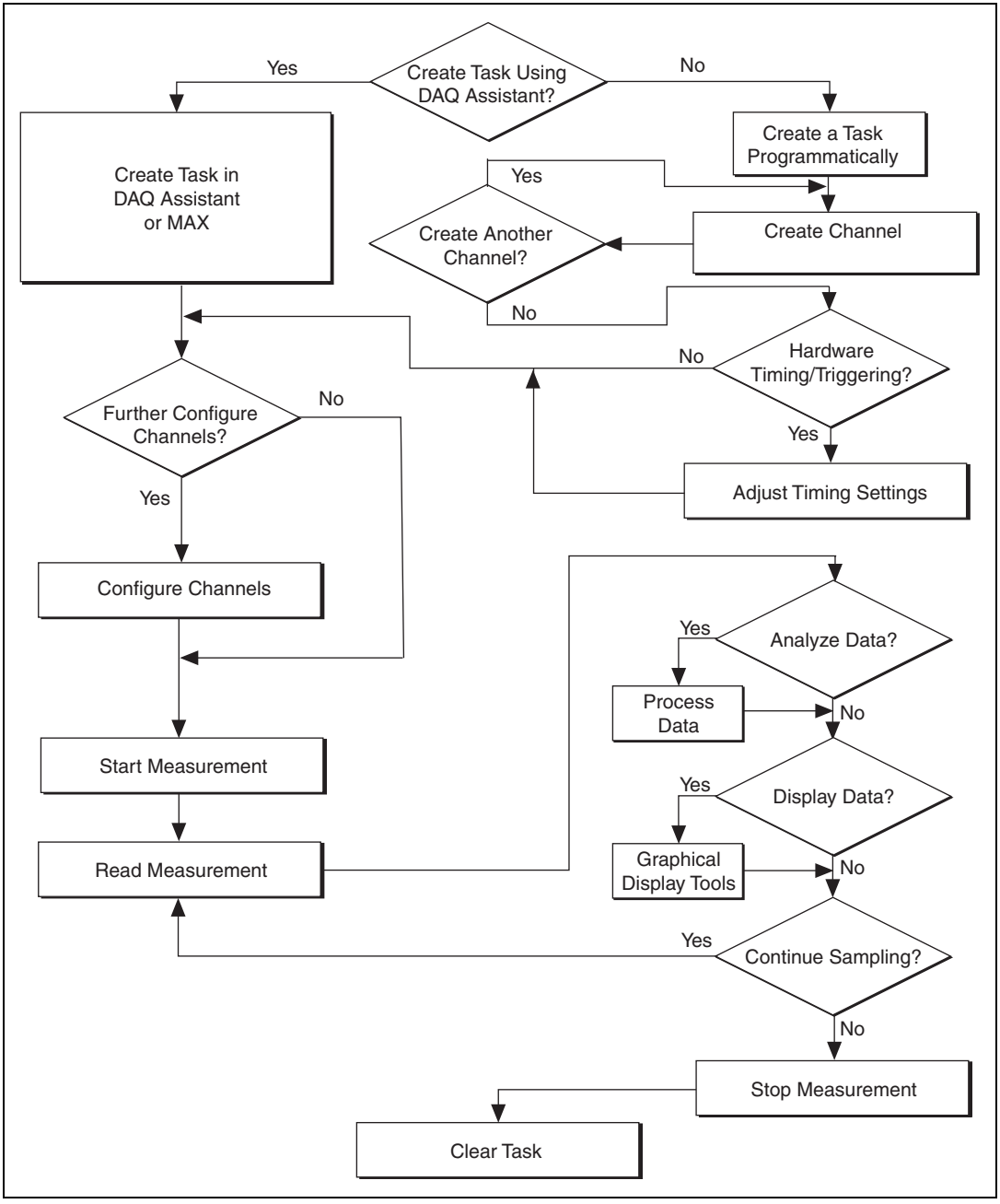


Figure 5-1. Typical Program Flowchart for Voltage Measurement Channels

General Discussion of Typical Flowchart

The following sections briefly discuss some considerations for a few of the steps in Figure 5-1. These sections are meant to give an overview of some of the options and features available when programming with NI-DAQmx.

Creating a Task Using DAQ Assistant or Programmatically

When creating an application, you must first decide whether to create the appropriate task using the DAQ Assistant or programmatically in the ADE.

Developing your application using DAQ Assistant gives you the ability to configure most settings such as measurement type, selection of channels, excitation voltage, signal input limits, task timing, and task triggering. You can access the DAQ Assistant through MAX or your NI ADE. Choosing to use the DAQ Assistant can simplify the development of your application. NI recommends creating tasks using the DAQ Assistant for ease of use, when using a sensor that requires complex scaling, or when many properties differ between channels in the same task.

If you are using an ADE other than an NI ADE, or if you want to explicitly create and configure a task for a certain type of acquisition, you can programmatically create the task from your ADE using functions or VIs. If you create a task using the DAQ Assistant, you can still further configure the individual properties of the task programmatically with functions or property nodes in your ADE. NI recommends creating a task programmatically if you need explicit control of programmatically adjustable properties of the DAQ system.

Programmatically adjusting properties for a task created in the DAQ Assistant overrides the original, or default, settings only for that session. The changes are not saved to the task configuration. The next time you load the task, the task uses the settings originally configured in the DAQ Assistant.

Adjusting Timing and Triggering

There are several timing properties that you can configure through the DAQ Assistant or programmatically using function calls or property nodes. If you create a task in the DAQ Assistant, you can still modify the timing properties of the task programmatically in your application.

When programmatically adjusting timing settings, you can set the task to acquire continuously, acquire a buffer of samples, or acquire one point at a time. For continuous acquisition, you must use a while loop around the acquisition components even if you configured the task for continuous acquisition using MAX or the DAQ Assistant. For continuous and buffered acquisitions, you can set the acquisition rate and the number of samples to read in the DAQ Assistant or programmatically in your application. By default, the clock settings are automatically set by an internal clock based on the requested sample rate. You also can select advanced features such as clock settings that specify an external clock source, internal routing of the clock source, or select the active edge of the clock signal.

Configuring Channel Properties

All ADEs used to configure the SCXI-1141/1142/1143 access an underlying set of NI-DAQmx properties. Table 5-1 shows some of these properties. You can use Table 5-1 to determine what kind of properties you need to set to configure the module for your application. For a complete list of NI-DAQmx properties, refer to your ADE help file.

Note You cannot adjust some properties while a task is running. For these properties, you must stop the task, make the adjustment, and re-start the application. Tables 5-1 through 5-4 assume all properties are configured before the task is started.

Table 5-1. NI-DAQmx Voltage Measurement Properties

Property	Short Name	Description
Analog Input»Maximum Value	AI.Max	Specifies the maximum value you expect to measure. The SCXI-1141/1142/1143 gain and E/M Series DAQ device range are computed automatically from this value.
Analog Input»Minimum Value	AI.Min	Specifies the minimum value you expect to measure. The SCXI-1141/1142/1143 gain and E/M Series DAQ device range are computed automatically from this value.

Table 5-1. NI-DAQmx Voltage Measurement Properties (Continued)

Property	Short Name	Description
Analog Input»General Properties»Advanced»Gain and Offset»Gain Value	AI.Gain	Specifies a gain factor to apply to the signal conditioning portion of the channel. The SCXI-1141/1142/1143 supports 1, 2, 5, 10, 20, 50, or 100.
Analog Input»General Properties»Advanced»High Accuracy Settings»Auto Zero Mode	AI.AutoZeroMode	Specifies when to measure ground. NI-DAQmx subtracts the measured ground voltage from every sample.
Analog Input»General Properties»Advanced»Input Configuration»Coupling	AI.Coupling	Specifies the input coupling of the channel. The SCXI-1141/1142/1143 supports DC and GND coupling.
Analog Input»General Properties»Filter»Analog Lowpass»Cutoff Frequency	AI. LowPass.CutoffFreq	Specifies the lowpass cutoff frequency

Table 5-2. NI-DAQmx Thermocouple Measurement Properties

Property	Short Name	Description
Analog Input»Temperature» Thermocouple»Type	AI.Thrmcpl.Type	Specifies the type of thermocouple connected to the channel.
Analog Input»Temperature» Thermocouple»ScaleType	AI.Thrmcpl.ScaleType	Specifies the method or equation form that the thermocouple scale uses.

Table 5-3. NI-DAQmx RTD Measurement Properties

Property	Short Name	Description
Analog Input»Temperature» RTD»Type	AI.RTD.Type	Specifies the type of RTD connected to the channel.
Analog Input»Temperature» RTD»R0	AI.RTD.R0	Specifies the resistance in ohms of the sensor at 0 °C.
Analog Input»Temperature» RTD»Custom»A, B, C	AI.RTD.A AI.RTD.B AI.RTD.C	Specifies the A, B, or C constant of the Callendar-Van Dusen equation when using a custom RTD type.
Analog Input»General Properties» Signal Conditioning»Resistance Configuration	AI.Resistance.Cfg	Specifies the resistance configuration for the channel, such as 2-wire, 3-wire, or 4-wire.

Table 5-4. NI-DAQmx Thermistor Measurement Properties

Property	Short Name	Description
Analog Input»Temperature» Thermistor»R1	AI.Thrmistr.R1	Specifies the resistance in ohms of the sensor at 0 °C.
Analog Input»Temperature» Thermistor»Custom»A, B, C	AI.Thrmistr.A AI.Thrmistr.B AI.Thrmistr.C	Specifies the A, B, or C constant of the Steinhart-Hart thermistor equation, which NI-DAQmx uses to scale thermistors.

Table 5-5. NI-DAQmx Current Measurement Properties

Property	Short Name	Description
Analog Input»General Properties» Signal Conditioning»Current Shunt Resistors»Location	AI.CurrentShunt.Loc	Specifies whether the shunt resistance location is internal or external.
Analog Input»General Properties» Signal Conditioning»Current Shunt Resistor»Value	AI.CurrentShunt.Resistance	Specifies the resistance, in ohms, of the external shunt resistance.

Note This is *not* a complete list of NI-DAQmx properties and does not include every property you may need to configure your application. It is a representative sample of important properties to configure for voltage measurements. For a complete list of NI-DAQmx properties and more information about NI-DAQmx properties, refer to your ADE help file.

Acquiring, Analyzing, and Presenting

After configuring the task and channels, you can start the acquisition, read measurements, analyze the data returned, and display it according to the needs of your application. Typical methods of analysis include digital filtering, averaging data, performing harmonic analysis, applying a custom scale, or adjusting measurements mathematically.

NI provides powerful analysis toolsets for each NI ADE to help you perform advanced analysis on the data without requiring you to have a programming background. After you acquire the data and perform any required analysis, it is useful to display the data in a graphical form or log it to a file. NI ADEs provide easy-to-use tools for graphical display, such as charts, graphs, slide controls, and gauge indicators. NI ADEs have tools that allow you to easily save the data to files such as spread sheets for easy viewing, ASCII files for universality, or binary files for smaller file sizes.

Completing the Application

After you have completed the measurement, analysis, and presentation of the data, it is important to stop and clear the task. This releases any memory used by the task and frees up the DAQ hardware for use in another task.

Note In LabVIEW, tasks are automatically cleared.

Developing an Application Using LabVIEW

This section describes in more detail the steps shown in the typical program flowchart in Figure 5-1, such as how to create a task in LabVIEW and configure the channels of the SCXI-1141/1142/1143. If you need more information or for further instructions, select **Help»VI, Function, & How-To Help** from the LabVIEW menu bar.

Note Except where otherwise stated, the VIs in Table 5-6 are located on the **Functions» All Functions»NI Measurements»DAQmx - Data Acquisition** subpalette and accompanying subpalettes in LabVIEW.

Table 5-6. Programming a Task in LabVIEW

Flowchart Step	VI or Program Step
Create Task in DAQ Assistant	Create a `DAQmx Task Name Control` located on the **Controls»All Controls»I/O»DAQmx Name Controls** subpalette, right-click it, and select `New Task (DAQ Assistant)`.
Create a Task Programmatically (optional)	`DAQmx Create Task.vi` located on the **Functions» All Functions»NI Measurements»DAQmx - Data Acquisition»DAQmx Advanced Task Options** subpalette—This VI is optional if you created and configured the task using the DAQ Assistant. However, if you use it in LabVIEW, any changes you make to the task are not saved to a task in MAX.
Create Virtual Channel(s)	`DAQMX Create Virtual Channel.vi` located on the **Functions»All Functions»NI Measurements»DAQmx - Data Acquisition** subpalette—Use this VI to add virtual channels to the task. Select the type of virtual channel based on the measurement you plan to perform.
Adjust Timing Settings (optional)	`DAQmx Timing.vi` (Sample Clock by default)—This VI is optional if you created and configured the task using the DAQ Assistant. Any timing settings modified with this VI are not saved in the DAQ Assistant. They are only available for the present session.
Configure Channels (optional)	NI-DAQmx Channel Property Node, refer to the *Using a NI-DAQmx Channel Property Node in LabVIEW* section for more information. This step is optional if you created and fully configured the channels using the DAQ Assistant. Any channel modifications made with a channel property node are not saved in the task in the DAQ Assistant. They are only available for the present session.
Start Measurement	`DAQmx Start Task.vi`
Read Measurement	`DAQmx Read.vi`
Analyze Data	Some examples of data analysis include filtering, scaling, harmonic analysis, or level checking. Some data analysis tools are located on the **Functions»Signal Analysis** subpalette and on the **Functions»All Functions»Analyze** subpalette.

Table 5-6. Programming a Task in LabVIEW (Continued)

Flowchart Step	VI or Program Step
Display Data	You can use graphical tools such as charts, gauges, and graphs to display the data. Some display tools are located on the **Controls»All Controls»Numeric»Numeric Indicator** subpalette and **Controls»All Controls»Graph** subpalette.
Continue Sampling	For continuous sampling, use a While Loop. If you are using hardware timing, you also need to set the `DAQmx Timing.vi` sample mode to Continuous Samples. To do this, right-click the terminal of the `DAQmx Timing.vi` labeled **sample mode** and click **Create»Constant**. Click the box that opens on the block diagram and select **Continuous Samples**.
Stop Measurement	`DAQmx Stop Task.vi` (This VI is optional, clearing the task automatically stops the task.)
Clear Task	`DAQmx Clear Task.vi`

Using a NI-DAQmx Channel Property Node in LabVIEW

You can use property nodes in LabVIEW to manually configure the channels. To create a LabVIEW property node, complete the following steps:

1. Launch LabVIEW.
2. Create the property node in a new VI or in an existing VI.
3. Open the block diagram view.
4. From the **Functions** toolbox, select **All Functions»NI Measurements»DAQmx - Data Acquisition**, and select `DAQmx Channel Property Node`.
5. The **ActiveChans** property is displayed by default. This allows you to specify exactly what channel(s) you want to configure. If you want to configure several channels with different properties, separate the lists of properties with another **Active Channels** box and assign the appropriate channel to each list of properties.

Note If you do not use Active Channels, the properties are set on all of the channels in the task.

6. Right-click **ActiveChans**, and select **Add Element**. Left-click the new **ActiveChans** box. Navigate through the menus, and select the property you wish to define.
7. Change the property to read or write to either get the property or write a new value. Right-click the property, go to **Change To**, and select **Write**, **Read**, or **Default Value**.
8. After you have added the property to the property node, right-click the terminal to change the attributes of the property, add a control, constant, or indicator.
9. To add another property to the property node, right-click an existing property and left-click **Add Element**. To change the new property, left-click it and select the property you wish to define.

Note Refer to the *LabVIEW Help* for information about property nodes and specific NI-DAQmx properties.

Specifying Channel Strings in NI-DAQmx

Use the channel input of **DAQmx Create Channel** to specify the SCXI-1141/1142/1143 channels. The input control/constant has a pull-down menu showing all available external channels. The strings take one of the following forms:

- single device identifier/channel number—for example `SC1Mod1/ch0`
- multiple, noncontinuous channels—for example `SC1Mod1/ch0`, `SC1Mod1/ch4`.
- multiple continuous channels—for example `SC1Mod1/ch0:4` (channels 0 through 4)

When you have a task containing SCXI-1141/1142/1143 channels, you can set the properties of the channels programmatically using the **DAQmx Channel Property Node**.

Text Based ADEs

You can use text based ADEs such as LabWindows/CVI, Measurement Studio, Visual Basic 6, .NET, and C# to create code for using the SCXI-1141/1142/1143.

LabWindows/CVI

LabWindows/CVI works with the **DAQ Assistant** in MAX to generate code for an voltage measurement task. You can then use the appropriate function call to modify the task. To create a configurable channel or task in LabWindows/CVI, complete the following steps:

1. Launch LabWindows/CVI.
2. Open a new or existing project.
3. From the menu bar, select **Tools»Create/Edit DAQmx Tasks**.
4. Choose **Create New Task In MAX** or **Create New Task In Project** to load the DAQ Assistant.
5. The DAQ Assistant creates the code for the task based on the parameters you define in MAX and the device defaults. To change a property of the channel programmatically, use the `DAQmxSetChanAttribute` function.

Note Refer to the *NI LabWindows/CVI Help* for more information on creating NI-DAQmx tasks in LabWindows/CVI and NI-DAQmx property information.

Measurement Studio (Visual Basic 6, .NET, and C#)

When creating an voltage measurement task in Visual Basic 6, .NET and C#, follow the general programming flow in Figure 5-1. You can then use the appropriate function calls to modify the task. This example creates a new task and configures an NI-DAQmx voltage measurement channel on the SCXI-1141/1142/1143. You can use the same functions for Visual Basic 6, .NET and C#.

The following text is a function prototype example:

```
void AIChannelCollection.CreateVoltageChannel(
    System.String physicalChannelName,
    System.String nameToAssignChannel,
    System.Double minVal,
    System.Double maxVal);
```

To actually create and configure the channel, you would enter something resembling the following example code:

```
Task myTask = new
NationalInstruments.DAQmx.Task("myTaskName");
MyTask.DAQmxCreateAIVoltageChan (
    "SC1Mod1/ai0", // System.String physicalChannelName
    "Voltage0", // System.String nameToAssignChannel
    -10.0, // System.Double minVal
    10.0); // System.Double maxVal
// setting attributes after the channel is created
AIChannel myChannel = myTask.AIChannels["Voltage0"];
myChannel.AutoZeroMode = kAutoZeroTypeOnce;
```

Modify the example code above or the code from one of the shipping examples as needed to suit your application.

Note You can create and configure the voltage measurement task in MAX and load it into your application with the function call `NationalInstruments.DAQmx.DaqSystem.Local.LoadTask`.

Refer to the *NI Measurement Studio Help* for more information on creating NI-DAQmx tasks in LabWindows/CVI and NI-DAQmx property information.

Programmable NI-DAQmx Properties

All of the different ADEs that configure the SCXI-1141/1142/1143 access an underlying set of NI-DAQmx properties. Tables 5-1, 5-2, and 5-3 provide a list of some of the properties that configure the SCXI-1141/1142/1143. You can use this list to determine what kind of properties you need to set to configure the device for your application. For a complete list of NI-DAQmx properties, refer to your ADE help file.

Note Tables 5-1, 5-2, and 5-3 are *not* complete lists of NI-DAQmx properties and do not include every property you may need to configure voltage measurements. It is a representative sample of important properties to configure voltage measurements. For a complete list of NI-DAQmx properties and more information on NI-DAQmx properties, refer to your ADE help file.

Calibration

The SCXI-1141/1142/1143 is shipped with a calibration certificate and is calibrated at the factory to the specifications described in Appendix A, *Specifications*. Calibration constants are stored inside the calibration EEPROM and provide software correction values your application development software uses to correct the measurements for both offset and gain errors in the module.

External Calibration

If you have an accurate calibrator and DMM, you can externally calibrate the SCXI-1141/1142/1143 gain and offset constants using NI-DAQmx functions.

Most external calibration documents for SCXI modules are available to download from `ni.com/calibration` by clicking **Manual Calibration Procedures**. For external calibration of modules not listed there, Basic Calibration Service or Detailed Calibration Service is recommended. You can get information about both of these calibration services from `ni.com/calibration`. NI recommends performing an external calibration once a year.

A

Specifications

This appendix lists the specifications for the SCXI-1141/1142/1143 module. These specifications are typical at 25 °C unless otherwise noted.

Amplifier Characteristics

Number of channels ..... 8 differential

Output signal range ..... ±5 V

Channel gains (software-selectable) 1, 2, 5, 10, 20, 50, 100

Input overvoltage protection

- Powered on ..... ±30 V
- Powered off ..... ±15 V

Input coupling ..... DC (AC available with SCXI-1304 or SCXI-1305 terminal block)

Input impedance

- Powered on ..... 10 GΩ in parallel with 40 pF
- Powered off ..... 2.4 kΩ

Input bias current ..... 450 pA

Input bias current temperature coefficient ..... 0.8 pA/°C

Input offset current ..... 250 pA

Common-mode rejection ratio ..... 60 dB (G = 1)

DC gain error .....±0.6% before calibration,
±0.02% after calibration[1]

DC input offset ..... $\left(10 + \frac{9.5}{Gain}\right)$ mV max

Filter Characteristics

Filter type

SCXI-1141 module.....8th-order elliptic

SCXI-1142 module.....8th-order Bessel

SCXI-1143 module.....8th-order Butterworth

Filter architecture.....Switched capacitor with prefilters and postfilters

Rolloff rate.....135 dB/octave

Cutoff frequency (f_c) range.....10 Hz to 25 kHz

Cutoff choices (software-selectable) .....Divided from 100 kHz or external clock (for example, 25 kHz, 20 kHz, 16.7 kHz, 14.3 kHz, or from external)

Passband ripple
(SCXI-1141 module only).....0.2 dB, DC to f_c

Phase matching
(SCXI-1142 only).....3° max error at f_c

Stopband attenuation

SCXI-1141module.....80 dB at $1.5 \times f_c$

SCXI-1142 module.....80 dB at $6 \times f_c$

SCXI-1143 module.....80 dB at $3.2 \times f_c$

Prefilter aliasing rejection.....> 80 dB below $99 \times f_c$
> 40 dB above $99 \times f_c$

Sampled image + clock feedthrough .....<–75 dB

[1] SCXI-1141/1142/1143 module factory calibration conditions: $V_{in}(-) = 0$ V, $V_{in}(+) = \pm$fullscale

Bandwidth and response time

Table A-1. Settling Time with Respect to Cutoff Frequency

Module	Bandwidth	Step Response Settling Time in ms (Full-Scale Input Step)		
		±1%	**±0.1%**	**±0.024%**
SCXI-1141	10	5250	10805	14585
	100	103	4500	7380
	1000	10	887	4090
	25000	0.575	0.97	2600
SCXI-1142	10	3595	9335	13960
	100	4480	8085	11365
	1000	815	5965	9590
	25000	19.55	250	3174
SCXI-1143	10	5000	10676	13514
	100	547	8140	11567
	1000	270	6207	10419
	25000	73	1399	4838

System Noise

THD

1 kHz..... –70 dB

0–25 kHz ..... –60 dB

Input noise..... 30 nV $\times \sqrt{f_c}$

Output noise ..... 500 μV_{rms}

Stability

DC gain temperature coefficient.....20 ppm/°C

Input offset drift.....$\left(20 + \frac{32}{Gain}\right)$ µV/°C typ

$\left(60 + \frac{100}{Gain}\right)$ µV/°C max

AC gain temperature coefficient.....280 ppm/°C

Digital Input/Output

EXT CLK pin input voltage
with respect to DIG GND.....5.5 V max
–0.5 V min

Absolute maximum voltage input
rating with respect to DIG GND.....–0.5 to 5.5 V

Digital input referenced to DIG GND

V_{IH}, input logic high voltage .....2 V min

V_{IL}, input logic low voltage.....0.8 V max

Digital output referenced to DIG GND

V_{OH}, output logic high voltage .....3.7 V min at 4 mA

V_{OL}, output logic low voltage .....0.4 V max at 4 mA

Physical

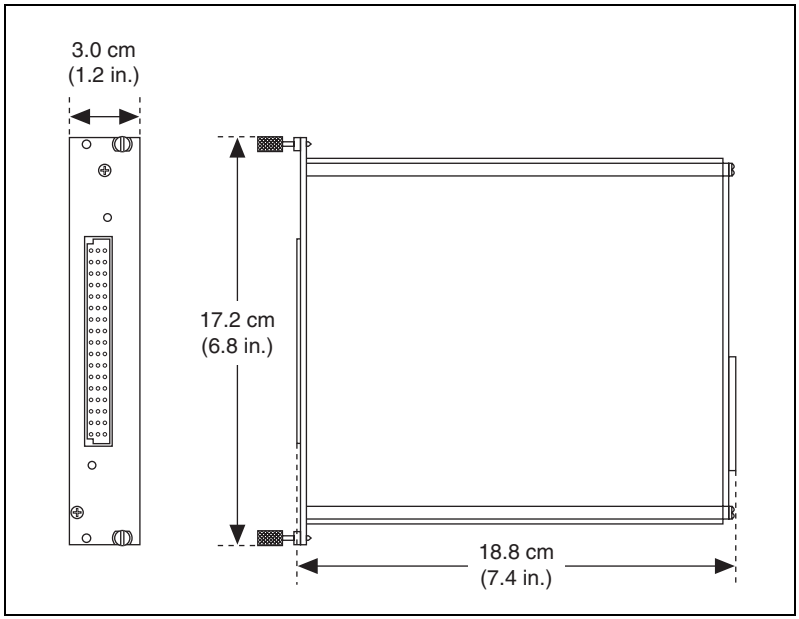


Figure A-1. SCXI-1141/1142/1143 Dimensions

Weight

SCXI-1141 and SCXI-1143 ..... 623 g (22.0 oz)

SCXI-1142 ..... 676 g (22.8 oz)

I/O connectors

Rear connector ..... 50-pin male ribbon-cable

Front connector ..... 96-pin DIN C male (screw-terminal adapters available)

Maximum Working Voltage

Maximum working voltage refers to the signal voltage plus the common-mode voltage.

Channel-to-earth..... ±5 V, Measurement Category I

Channel-to-channel ..... ±10 V, Measurement Category I

Environmental

Operating temperature .....0 to 50 °C

Storage temperature .....–20 to 70 °C

Humidity .....10 to 90% RH, noncondensing

Maximum altitude.....2,000 m

Pollution Degree (indoor use only) 2

Safety

This product is designed to meet the requirements of the following standards of safety for electrical equipment for measurement, control, and laboratory use:

- IEC 61010-1, EN-61010-1
- UL 61010-1, CSA 61010-1

Note For UL and other safety certifications, refer to the product label or visit `ni.com/certification`, search by model number or product line, and click the appropriate link in the Certification column.

Electromagnetic Compatibility

This product is designed to meet the requirements of the following standards of EMC for electrical equipment for measurement, control, and laboratory use:

- EN 61326 EMC requirements; Minimum Immunity
- EN 55011 Emissions; Group 1, Class A
- CE, C-Tick, ICES, and FCC Part 15 Emissions; Class A

Note For EMC compliance, operate this device according to product documentation.

CE Compliance

This product meets the essential requirements of applicable European Directives, as amended for CE marking, as follows:

- 73/23/EEC; Low-Voltage Directive (safety)
- 89/336/EEC; Electromagnetic Compatibility Directive (EMC)

Note Refer to the Declaration of Conformity (DoC) for this product for any additional regulatory compliance information. To obtain the DoC for this product, visit `ni.com/certification`, search by model number or product line, and click the appropriate link in the Certification column.

Waste Electrical and Electronic Equipment (WEEE)

EU Customers At the end of their life cycle, all products *must* be sent to a WEEE recycling center. For more information about WEEE recycling centers and National Instruments WEEE initiatives, visit `ni.com/environment/weee.htm`.

B

Removing the SCXI-1141/1142/1143 Module

This appendix describes how to remove the SCXI-1141/1142/1143 module from an SCXI chassis and from MAX.

Removing the SCXI-1141/1142/1143 Module from MAX

To remove a module from MAX, complete the following steps after launching MAX:

1. Expand **Devices and Interfaces** to display the list of installed devices and interfaces.
2. Expand **NI-DAQmx Devices** to display the chassis.
3. Expand the appropriate chassis to display the installed modules.
4. Right-click the module or chassis you want to delete and click **Delete**.
5. You are presented with a confirmation window. Click **Yes** to continue deleting the module or chassis or **No** to cancel this action.

Note Deleting the SCXI chassis deletes all modules in the chassis. All configuration information for these modules is also deleted.

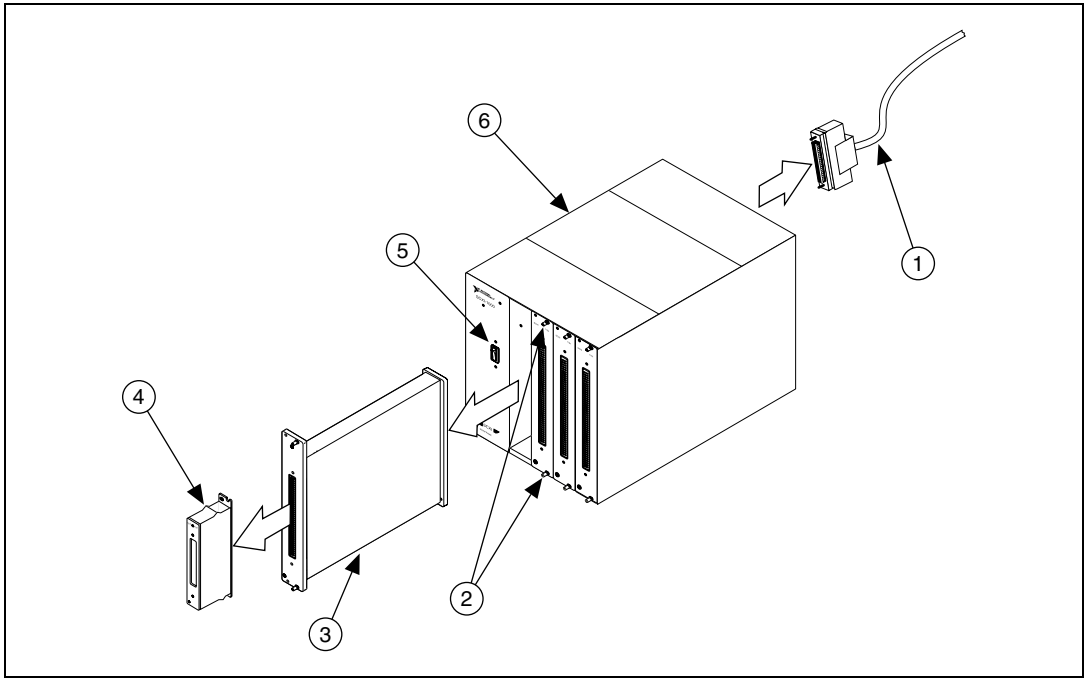
The SCXI chassis and/or SCXI module(s) should now be removed from the list of installed devices in MAX.

Removing the SCXI-1141/1142/1143 Module from an SCXI Chassis

Consult the documentation for the chassis and accessories for additional instructions and precautions. To remove the SCXI-1141/1142/1143 module from a chassis, complete the following steps while referring to Figure B-1:

1. Power off the chassis. Do *not* remove the SCXI-1141/1142/1143 module from a chassis that is powered on.

2. If the SCXI-1141/1142/1143 is the module cabled to the E/M Series DAQ device, disconnect the cable.
3. Remove any terminal block that connects to the SCXI-1141/1142/1143.
4. Rotate the thumbscrews that secure the SCXI-1141/1142/1143 to the chassis counterclockwise until they are loose, but do not completely remove the thumbscrews.
5. Remove the SCXI-1141/1142/1143 by pulling steadily on both thumbscrews until the module slides completely out.



1	Cable	3	SCXI-1141/1142/1143 Module	5	SCXI Chassis Power Switch
2	SCXI Module Thumbscrews	4	Terminal Block	6	SCXI Chassis

Figure B-1. Removing the SCXI-1141/1142/1143 Module

C

Common Questions

This appendix lists common questions related to the use of the SCXI-1141/1142/1143.

Which version of NI-DAQ works with the SCXI-1141/1142/1143, and how do I get the most current version of NI-DAQmx?

NI recommends that you have NI-DAQmx 8.3 or later. Visit `ni.com` and click **Drivers and Updates**. In the **Product Line** drop-down menu locate **Multifunction DAQ**. Select the appropriate information for your application in the remaining drop-down menus and click **Go**.

I have gone over the *Verifying the SCXI-1141/1142/1143 Installation in Software* section of Chapter 1, *About the SCXI-1141/1142/1143*, yet I still cannot correctly test and verify that my SCXI-1141/1142/1143 is working. What should I do now?

Unfortunately, there is always the chance that one or more components in the system are not operating correctly. You may have to call or email a technical support representative. The technical support representative often suggests additional troubleshooting measures. If requesting technical support by phone, have the system nearby so you can try these measures immediately. NI contact information is listed in the *Technical Support Information* document.

In NI-DAQmx, can I use channels of different measurement types in the same task?

Yes, you can set up the channels programmatically or through the DAQ Assistant.

Will MAX allow me to configure two SCXI-1141/1142/1143 modules that are in the same chassis, in multiplexed mode, with two different E/M Series DAQ devices?

No.

Can I configure the SCXI-1141/1142/1143 for use in parallel mode?

You can configure the SCXI-1141/1142/1143 for parallel mode using either NI-DAQmx or Traditional NI-DAQ (Legacy). For more information, refer to Chapter 4, *Theory of Operation*.

How can I get the most accurate measurements with the SCXI-1141/1142/1143?

You can use the AutoZero functionality of the SCXI-1141/1142/1143 once at the beginning of a measurement to compensate for any offset and achieve the best accuracy. For more information about the AutoZero mode, refer to Chapter 3, *Configuring and Testing*.

How do I cascade the SCXI-1141/1142/1143 with another module?

For more information about cascading the SCXI-1141/1142/1143, refer to `ni.com/info` and use info code `exy7sh`.

Which digital lines are unavailable on the E/M Series DAQ device if it is cabled to an SCXI-1141/1142/1143 module?

Table C-1 shows the digital lines used by the SCXI-1141/1142/1143 for communication and scanning. These lines are unavailable for general-purpose digital I/O if the SCXI-1141/1142/1143 is connected to the E/M Series DAQ device.

Table C-1. Digital SIgnals on the SCXI-1141/1142/1143

E/M Series DAQ Device Signal Name	NI-DAQmx SCXI Signal Name	Traditional NI-DAQ (Legacy) SCXI Signal Name	50-Pin Connector	68-Pin Connector	Direction[1]
DIO0	P0.0	SER DAT IN	25	52	Output
DIO4	P0.4	SER DAT OUT	26	19	Input
DIO1	P0.1	DAQ D*/A	27	17	Output
DIO2	P0.2	SLOT 0 SEL*	29	49	Output
SCAN CLK	AI HOLD COMP, AI HOLD	SCAN CLK	36	46	Output
EXT STROBE*	EXT STROBE*	SER CLK	37	45	Input

[1] With respect to the E/M Series DAQ device.

In LabVIEW, can I use different input limits for the same SCXI-1141/1142/1143 channel if I repeat the channel in the SCXI channel string array?

No. The SCXI-1141/1142/1143 cannot dynamically change the gain settings during scanning. Therefore, group channels with similar input ranges together in the channel string array. Make sure that repeated channels in different indices of the channel string array have the same input limits in the corresponding input limits array.

In LabVIEW, can I use a VI to change my SCXI-1141/1142/1143 configuration settings?

Yes. You can change the configuration settings in NI-DAQmx using NI-DAQmx Tasks. In Traditional NI-DAQ (Legacy) you can use the AI Parameter VI to change all the SCXI-1141/1142/1143 configuration settings. For more information, refer to Chapter 5, *Using the SCXI-1141/1142/1143 Module*.

Some SCXI modules permit flexible scanning. Does the SCXI-1141/1142/1143 module permit flexible scanning?

No. You must scan the channels on the SCXI-1141/1142/1143 module in consecutive, ascending order. However, you can start the scan with any channel.

Are there any cabling restrictions when using an SCXI-1141/1142/1143 module with a plug-in E/M Series DAQ device?

Yes. If a chassis contains an SCXI-1520, SCXI-1530/1531, or SCXI-1140 module, at least one of these modules must be the cabled module. A cabled module is the module connected directly to the E/M Series DAQ device. This ensures that a timing signal is available for use by all simultaneous-sampling SCXI modules in the chassis.

What is the power-on state of the SCXI-1141/1142/1143 multiplexer, analog bus switches, and configuration settings?

The multiplexer, analog bus switches, and configuration settings are not in a known state immediately after power on. All hardware settings are programmed automatically when beginning an acquisition in LabVIEW or a test panel in MAX.

Which accessories can I use to connect signals to the front of the SCXI-1141/1142/1143 module?

For information regarding available accessories, refer to Chapter 1, *About the SCXI-1141/1142/1143*.

How do I control the gain using LabVIEW?

The gain of each SCXI-1141/1142/1143 channel is automatically set based on the channel limits used in setting up the acquisition. You usually use the LabVIEW DAQmx Create Channel VI to set the channel limits. If the channel limits are not explicitly set, the SCXI-1141/1142/1143 defaults to the gain setting entered when the module was configured using MAX. For more information, refer to Chapter 3, *Configuring and Testing*.

How do I perform external triggering using the SCXI-1141/1142/1143?

For analog triggering, use the data acquisition device analog triggering functionality through pin PFI 0. Verify that the E/M Series DAQ device supports analog triggering. For more information about analog triggering with the SCXI-1141/1142/1143, refer to `ni.com/info` and use the info code `rdahtu`.

For digital triggering, use the data acquisition device digital triggering functionality through pin PFI 0. All E/M Series DAQ devices support digital triggering. For more information about digital triggering with the SCXI-1141/1142/1143, refer to the DAQ device help file.

Glossary

Symbol	Prefix	Value
p	pico	10^{-12}
n	nano	10^{-9}
μ	micro	10^{-6}
m	milli	10^{-3}
k	kilo	10^{3}
M	mega	10^{6}
G	giga	10^{9}
T	tera	10^{12}

Symbols

°	degrees
>	greater than
≥	greater than or equal to
<	less than
≤	less than or equal to
–	negative of, or minus
Ω	ohms
%	percent
±	plus or minus
+	positive of, or plus

A

A	amperes
A GND	analog ground signal
A OUT	analog output signal
AC	alternating current
ADE	application development environment
aliasing	the consequence of sampling that causes signals with frequencies higher than half the sampling frequency to appear as lower frequency components

B

bias current	the small input current flowing into or out of the input terminals of an amplifier
BNC	a type of coaxial signal connector

C

C	Celsius
CMOS	complementary metal-oxide semiconductor
common-mode noise	noise that is found on both inputs of a differential amplifier
cutoff frequency	the frequency that defines the upper end of the passband of a lowpass filter

D

DAQ	data acquisition
DAQ D*/A	data acquisition board data/address line signal
dB	decibels
DC	direct current

DIG GND	digital ground signal
DIN	Deutsche Industrie Norme (German Industrial Standard)
DMM	digital multimeter

E

EEPROM	electrically erasable programmable read-only memory
EXT CLK	external clock signal

F

f_c	cutoff frequency
F_{ext}	external frequency

G

G	gain
gain error	the difference between the actual and intended gain of a system

H

hex	hexadecimal (base 16)
Hz	hertz

I

I/O	input/output
in.	inch
INTR*	interrupt signal

L

lowpass filter	a filter that passes signals below a cutoff frequency while blocking signals above that frequency

M

max	maximum
MB	megabytes
min	minutes, or minimum
MISO	Master-In-Slave-Out signal
MOSI	Master-Out-Slave-In signal
multiplex	to route one of many input signals to a single output

N

Nyquist frequency	the frequency that a sampling system can accurately reproduce, which is half the sampling frequency

O

offset error	the output of a system with a zero volt input
OUTPUT	output signal
OUTPUT REF	output reference signal

P

passband	the range of input frequencies that are passed to the filter output without attenuation
ppm	parts per million

R

rms	root mean square
rolloff	the ratio that a system attenuates signals in the stopband with respect to the passband, usually defined in decibels per octave
RSVD	reserved signal/bit

S

s	seconds
S/s	samples per second—used to express the rate at which a DAQ device samples an analog signal
sample	an instantaneous measurement of a signal, normally using an analog-to-digital convertor in a DAQ device
sample rate	the number of samples a system takes over a given time period, usually expressed in samples per second
scan	a collection of samples, usually with each sample coming from a different input channel
SCAN CLK	scan clock signal
SCXI	Signal Conditioning eXtensions for Instrumentation
SCXIbus	located in the rear of an SCXI chassis, the SCXIbus is the backplane that connects modules in the same chassis to each other
SER CLK	serial clock signal
SER DAT IN	serial data in signal
SER DAT OUT	serial data out signal
SLOT 0 SEL	slot 0 select signal
SPI CLK	serial peripheral interface clock signal
stopband	the portion of a frequency spectrum blocked by a filter

T

THD	total harmonic distortion
TTL	transistor-transistor logic

V

V	volts
VI	virtual instrument (a LabVIEW program)
V_{rms}	volts, root mean square

W

working voltage	the highest voltage that should be applied to a product during normal use, normally well under the breakdown voltage for safety margin

Index

A

A GND signal
  front connector (table), 2-3
  rear connector (table), 2-9
A OUT signal (table), 2-9
AC-coupled signal connections
  floating (figure), 2-6
  ground-offset (figure), 2-6
  ground-referenced (figure), 2-5
adjusting timing and triggering, 5-3
AI+<0..7+> signal (table), 2-3
AI–<0..7–> signal (table), 2-3
aliasing
  definition, 4-12
  example (figure), 4-12
  preventing, 4-12
amplifiers
  gain and offset correction, 4-4
  instrumentation amplifiers, 2-3
  specifications, A-1
  theory of operation, 4-3
analog input channels
  front connection
    common-mode rejection, 2-3
    exceeding maximum voltage (caution), 2-4
    maximum differential input voltage, 2-3
    SCXI-1304 or SCXI-1305 terminal block (note), 2-4
  signal connections (figure)
    floating, 2-5
    floating AC-coupled, 2-6
    ground-offset AC-coupled, 2-6
    ground-referenced, 2-4
    ground-referenced AC-coupled, 2-5
analog output
  multiplexed mode, 4-16
  parallel mode, 4-17
  signal connections, 2-11
antialiasing filter, using SCXI-1141/1142/1143 as, 4-12
application software, installation, 1-4
applications
  developing in NI-DAQmx, 5-1
    acquiring, analyzing, and presenting, 5-7
    completing, 5-7
    LabVIEW, 5-7
    program flowchart (figure), 5-2
    programmable properties, 5-12
    specifying channel strings, 5-10

B

bypassing filters, 4-16

C

calibration
  gain and offset correction, 4-4
  overview, 5-1
  SCXI-1141/1142/1143, 5-13
CE compliance specifications, A-7
channel properties, configuring, 5-4
channels, voltage measurement flowchart (figure), 5-2
common software-configurable settings
  gain/input range, 3-1
configuration
  channel properties, 5-4
  removing modules from MAX, B-1
  SCXI-1141/1142/1143
    common software settings, 3-1

settings in MAX
NI-DAQmx, 3-3
creating a global channel or task, 3-3
troubleshooting self-test verification, 1-5
verifying signal, 3-4
NI-DAQmx, 3-4
configuration register, 4-3
configuration settings, gain/input range, 3-1
configuring channel properties, 5-4
connectors
front signal connector
pin assignments (table), 2-2
conventions used in the manual, *iv*
creating a task
DAQ Assistant, 5-3
programmatically, 5-3
current measurement properties (table), 5-6
cutoff frequency for lowpass filters
passband signal components, 4-5
setting
formula for determining frequencies, 4-11
ranges for prefilters and postfilters (table), 4-15
using external clock input, 4-14

D

D GND signal (table), 2-3
DAQ Assistant, creating a task, 5-3
DAQ D*/A signal
digital I/O connections, 2-11
DC-correction circuitry, lowpass filters, 4-15
digital control circuitry, 4-3
digital I/O signal connections
front connector, 2-6
rear connector
emulation of SCXIbus communication signals, 2-11
SCXIbus to SCXI-1141/1142/1143 pin equivalencies (table), 2-12
digital I/O specifications, A-4
documentation
conventions used in the manual, *iv*
National Instruments, 1-3
SCXI-1141/1142/1143, 1-2

E

EEPROM
gain and offset correction, 4-4
electromagnetic compatibility specifications, A-6
elliptic filters, 4-5
environmental specifications, A-6
EXT CLK signal
description (table), 2-3
digital I/O connections, 2-6
external clock input, for setting cutoff frequencies, 4-14

F

filter bypass mode, 4-16
filter specifications, A-2
filter theory
See also lowpass filters
classification of filters, 4-5
step input response (figure), 4-6
transfer functions (figure), 4-5
floating signal connections (figure), 2-5
AC-coupled (figure), 2-6
frequency dividers, 4-3
front connector
analog input channels
common-mode signal rejection, 2-3
exceeding maximum voltage (caution), 2-4
signal connections (figures), 2-4, 2-5, 2-6

signal descriptions (table), 2-3
front signal connector
pin assignments (figure), 2-2
functional overview of SCXI-1141. *See* theory of operation

G

gain and offset correction, 4-4
See also calibration
gain register, 4-3
gain/input range, configuration, 3-1
ground-offset AC-coupled signal connection (figure), 2-6
ground-referenced signal connections (figure), 2-4
AC-coupled (figure), 2-5

H

hardware, SCXI-1141/1142/1143, 1-2

I

input amplifiers. *See* amplifiers
installation
application software, 1-4
NI-DAQ, 1-4
removing SCXI-1141/1142/1143 from SCXI chassis, B-1
SCXI using NI-DAQmx, 1-5
SCXI-1141/1142/1143, 1-4
instrumentation amplifiers. *See* amplifiers

L

LabVIEW, 1-2
developing an application, 5-7
programming a task (table), 5-8
software, 1-2
using a NI-DAQmx channel property node, 5-9
LabWindows/CVI, 1-2
creating code for using SCXI-11141/1142/1143, 5-11
lowpass filters, 4-5
DC-correction circuitry, 4-15
external clock input, 4-14
filter bypass mode, 4-16
filter theory, 4-5
overload recovery, 4-15
performance of SCXI-1141 filters
magnitude response, 4-6
phase response, 4-8
response to step input (figure), 4-6
SCXI-1141/1142/1143 as antialiasing filter, 4-12
setting cutoff frequency, 4-11
specifications, A-2
transfer function characteristics (figure), 4-5

M

magnitude response, SCXI-1141/1142/1143 filters, 4-6
typical magnitude response (figure), 4-7
typical passband response (figure), 4-8
Measurement & Automation Explorer (MAX), B-1
configurable settings, 3-2
removing modules, B-1
self-test verification
troubleshooting, 1-5
measurement properties, NI-DAQmx
current (table), 5-6
RTD (table), 5-6
thermistor (table), 5-6
thermocouple (table), 5-5
voltage (table), 5-4

Measurement Studio, 1-2
creating code for using SCXI-11141/1142/1143, 5-11
Module ID register, 4-3
modules, installing, 1-4
multiplexed mode, analog output, 4-16

N

National Instruments documentation, 1-3
NI-DAQ, 1-2
driver software, 1-4
installation, 1-4
NI-DAQmx
configurable settings, 3-3
current measurement properties (table), 5-6
developing applications, 5-1
acquiring, analyzing, and presenting, 5-7
adjusting timing and triggering, 5-3
completing, 5-7
configuring channel properties, 5-4
LabVIEW, 5-7
NI-DAQmx channel property node, 5-9
program flowchart (figure), 5-2
programmable properties, 5-12
specifying channel strings, 5-10
RTD measurement properties (table), 5-6
thermistor measurement properties (table), 5-6
thermocouple measurement properties (table), 5-5
voltage measurement properties (table), 5-4
noise pickup, minimizing, 2-3
Nyquist frequency, 4-12

O

offset correction, 4-4
See also calibration
operation of SCXI-1141/1142/1143. *See* theory of operation
OUT CLK signal
description (table), 2-3
digital I/O connections, 2-6
overload recovery, lowpass filters, 4-15

P

parallel mode, analog output, 4-17
passband, lowpass filters, 4-5
performance of SCXI-1141/1142/1143 filters
magnitude response, 4-6
phase response, 4-8
phase response, SCXI-1141/1142/1143 filters
phase error (figure), 4-9
response characteristics (figure), 4-10
unit step response (figure), 4-11
physical specifications, A-5
pin assignments
front connector
signal description (table), 2-3
front signal connector (table), 2-2
rear signal connector
SCXIbus to SCXI-1141/1142/1143 pin equivalencies (table), 2-12
power-up state, 4-1

R

rear signal connector
analog output signal connections, 2-11
digital I/O signal connections
emulation of SCXIbus communication signals, 2-11
SCXIbus to SCXI-1141/1142/1143 pin equivalencies (table), 2-12

removing
modules from MAX, B-1
SCXI-1141/1142/1143 from SCXI chassis, B-1
requirements for getting started, 1-2
ripple, real filters, 4-6
RTD
measurement properties (table), 5-6

S

safety specifications, A-6
SCAN CLK signal
digital I/O connections, 2-12
SCXI chassis
installing the SCXI-1141/1142/1143 module, 1-4
SCXI-1141/1142/1143
calibration, 5-13
common software settings, 3-1
configuration settings, 3-1
dimensions (figure), A-5
documentation, 1-2
hardware, 1-2
measurements, 3-3
software, 1-2
using
LabWindows/CVI to create code, 5-11
Measurement Studio to create code, 5-11
SCXI-1141/1142/1143 modules
See also configuration, installation
block diagram, 4-2
overview, 1-1
requirements for getting started, 1-2
SCXI-1141/1142/1143 software installation, verifying, 1-5
SCXI-1304 or SCXI-1305 terminal block (note), 2-4
SCXIbus communication signals
emulation by digital I/O signal lines, 2-11
SCXIbus to SCXI-1141/1142/1143 pin equivalencies (table), 2-12
self-test verification, troubleshooting, 1-5
SER CLK signal
digital I/O connections, 2-11
SER DAT IN signal
digital I/O connections, 2-11
SER DAT OUT signal
digital I/O connections, 2-12
setting cutoff frequency for lowpass filters. *See* cutoff frequency for lowpass filters
signal connections
exceeding maximum ratings (caution), 2-1
front connector
analog input channels, 2-3
digital input and output, 2-6
signal descriptions (table), 2-3
front signal connector
pin assignments (table), 2-2
rear signal connector
analog output signal connections, 2-11
digital I/O signal connections, 2-11
signals
verifying, 3-4
NI-DAQmx, 3-4
SLOT 0 SEL* signal
digital I/O connections, 2-11
software
installation, SCXI-1141/1142/1143, verifying, 1-5
LabVIEW, 1-2
LabWindows/CVI, 1-2
Measurement Studio, 1-2
NI-DAQ, 1-2
SCXI-1141/1142/1143, 1-2

specifications
amplifier characteristics, A-1
CD compliance, A-7
digital I/O, A-4
electromagnetic compatibility, A-6
environmental characteristics, A-6
filter characteristics, A-2
physical, A-5
safety, A-6
stability, A-4
system noise, A-3
Waste Electrical and Electronic Equipment (WEEE), A-7
specifying channel strings in NI-DAQmx, 5-10
stability specifications, A-4
step input response of lowpass filters (figure), 4-6
stopband, 4-5
system noise specifications, A-3

T

theory of operation
block diagram, 4-2
digital control circuitry, 4-3
input amplifiers, 4-3
gain and offset correction, 4-4
lowpass filters
DC-correction circuitry, 4-15
external clock input, 4-14
filter theory, 4-5
magnitude response, 4-6
overload recovery, 4-15
performance, 4-6
phase response, 4-8
response to step input (figure), 4-6
SCXI-1141/1142/1143 as antialiasing filter, 4-12
setting cutoff frequency, 4-11
transfer function characteristics (figure), 4-5
major components of SCXI-1141, 4-1
power-up state, 4-1
thermistor, measurement properties (table), 5-6
thermocouple, measurement properties (table), 5-5
timing and triggering, adjusting, 5-3
transfer functions of lowpass filters
characteristics (figure), 4-5
purpose, 4-5
troubleshooting
NI-DAQmx, 1-5
self-test verification, 1-5

V

verifying
SCXI-1141/1142/1143 software installation, 1-5
signal, 3-4
NI-DAQmx, 3-4
troubleshooting, 1-5
Visual Basic
creating code for the SCXI-1141/1142/1143, 5-10

W

Waste Electrical and Electronic Equipment (WEEE) specification, A-7